Al Agassiz

QUARTERLY JOURNAL

OF

MICROSCOPICAL SCIENCE:

EDITED BY

JOSEPH FRANK PAYNE, M.B. Oxon., B.Sc. Lond.,
Fellow of Magdalen College, Oxford; Assistant Physician to St. Thomas's Hospital;

E. RAY LANKESTER, M.A., F.R.S.,
Fellow and Lecturer of Exeter College, Oxford; Professor of Zoology and Comparative Anatomy in University College, London;

AND

W. T. THISELTON DYER, M.A. Oxon., B.Sc. Lond., F.L.S.

VOLUME XV.—New Series.

With Illustrations on Wood and Stone.

LONDON:
J. & A. CHURCHILL, NEW BURLINGTON STREET.
1875.

CONTENTS.

CONTENTS OF No. LVII, N.S., JANUARY, 1875.

CONTENTS OF No. LVIII, N.S., APRIL, 1875.

CONTENTS OF No. LIX, N.S., JULY, 1875.

CONTENTS OF No. LX, N.S., OCTOBER, 1875.

MEMOIRS.

Observations *on the* Anatomy *of* Tænia mediocanellata. By Francis H. Welch, F.R.C.S., Surgeon, Army Medical Department, and Assistant to the Professor of Pathology, Army Medical School, Netley. (With Plates I & II.)

At first sight it may appear somewhat a work of supererogation to enter upon the anatomical details of any of the tapeworm species, so much having been done, especially by German observers, all of whom appear to have taken as the type of the genus, and as its common representative, the *Tænia solium.* Consequently the space allotted to the *Tænia mediocanellata* in the text-books has been very meagre in amount, the points only in which it appeared to diverge from the assumed common form being entered on. None but the sparsest illustrations of its anatomy are in existence, and, as far as I am aware, no complete exposition of its structure from an English source is to be found. But although the *T. solium,* as far as man is concerned as a habitat, may be the tapeworm more frequently observed in certain localities, yet, on the point of dispersion over the earth's area the *T. mediocanellata* (as far as present knowledge extends) seems unquestionably in the ascendancy, and, if so, rightly must be considered as the more common form infecting man, and also regarded as the type of the genus. Indeed, even in these islands, where the *T. solium* is supposed to predominate, it is difficult to come across an example of it, while on the other hand the *T. mediocanellata* may be obtained with comparative facility. Owing to the difficulty of procuring the head for identification, there can be little doubt that segments of the *T. mediocanellata* have often done duty in the eye of the observer as exemplifying the presence of its congener, the solitary worm; and the more the subject is inquired into the more dubious becomes the ordinary received opinion of the *T. solium* being the common tapeworm even of the British Isles. That the *T. mediocanellata* is extremely common in Malta and the Mediterranean generally, both among natives and the English garrison, I can personally vouch for, and in a minor degree also among the same classes in parts of British North America; also the post-mortem records of the Royal Victoria Hospital, Netley, illustrate examples of this parasite in invalids from India, Cape, Mauritius, Ceylon, Malta, and Gibraltar, generally solitary, occasionally more than one in the same host, and in individuals where its presence was not observed during life, while on the other hand I can find no notification of the occurrence of the *T. solium* among our wide-spread garrisons, and the same feature of comparative prevalence is shown in the preparations of the Netley Museum; and if to this we add the statement of Professor Aitken that it also "is the common tapeworm of the Continent," it is clear that, acting up to our present knowledge, we must reverse the prevalent opinion and regard the *T. mediocanellata* as the common form and as the type of the genus.

Owing to the parasite receiving so many illustrating examples, there is no lack of material in army life to work upon, and the result of an inquiry into its anatomy I have embodied in the present paper; some of the details are corroborative of previously made observations, others are opposed to them, while on certain points inquiry has been further extended.

The general aspect of the linearly arranged colony of flat white zooids embraced under the term "tapeworm," progressing in size from above downwards, is too well known to need description, and hence we may pass over major naked-eye characters common to the genus to enter at once on those details to be noted in the species under consideration.

Should we have an opportunity of examining specimens taken entire from the small intestines of the dead host we find that the actual length between individual colonies varies considerably, and chiefly in proportion to the state of contraction or otherwise of the component segments, ranging in fact from five to ten feet; and it is to be observed as regards this range of total length that should there be vitality still existent, and the contractility of the tissues excited by immersion in alcohol, the extreme measurement may by this means be curtailed so as closely to approximate, or even reach, the minimum length of five feet. The firmness of the segments resulting from this immersion in alcohol before muscular action has passed into the quiescence of death is of great assistance in making sections for microscopical examinations. It must also be noted that this contraction, which is mainly longitudinal in the colony, may modify somewhat the breadth and thickness of the individual segments as compared to their length, while leaving, however, the relative measurement of our component zooid to the other intact.

Taking as an example a colony 60 inches in length after alcoholic immersion, the following rough details were noted. —Head square shaped, tapering somewhat towards the neck, length $\frac{5}{100}$ in., breadth $\frac{6}{100}$ in., thickness $\frac{5}{100}$ in. Neck (merely the narrowest portion of the colony from which the head expands upwards and the segments downwards) oval in outline, $\frac{3\cdot4}{100}$ in. broad by $\frac{3}{100}$ in. thick. In the first inch from the neck were about 100 segments, averaging $\frac{1}{100}$ in. in length and $\frac{5}{100}$ in. in breadth. In the second inch 60 segments. In the four succeeding inches 126 segments, the lowermost $\frac{15}{100}$ in. broad, $\frac{4}{100}$ in. long, and $\frac{3}{100}$ in. thick. From 7th to 10th inch, 121 segments. From 11th to 14th, 70. From 15th to 18th, 64. From 19th to 22nd, 48. From 23rd to 26th, 40. From 27th to 30th, 33; the lowermost segment being $\frac{30}{100}$ in. broad, $\frac{7}{100}$ in. long, and $\frac{6}{100}$ in. thick. From 31st to 34th, 27. From 35th to 38th, 27. From 39th to 42nd, 21. From 43rd to 46th, 20. From 47th to 50th, 15; at 48 inches from head, the segments being equal in length and breadth, $\frac{25}{100}$ in. by $\frac{7}{100}$ in. in thickness. From 51st to 54th, 13. From 55th to 58th, 11. From 59th to 60th, 4; the last zooid being $\frac{17}{100}$ in. broad, $\frac{55}{100}$ in. long, and $\frac{5}{100}$ in. thick. In all 800 segments. Hence, from the neck to the 662nd segment, there is a gradual increase of the components of the colony in all dimensions, especially in breadth and thickness, and in a lesser ratio as regards the length; from the latter point the thickness of the segments continues somewhat to augment, while the length greatly advances accompanied by a corresponding decrease in breadth, until, at the 765th segment, length and breadth are equal; from the 765th to the terminal segment the thickness and breadth in especial gradually give way to advancing length; so that, viewing the colony either in front or laterally, there is a rapid tapering from the head to the neck, succeeded towards the centre by a progressive expansion which merges into a gradual decrease in body thickness towards the zooids ready to separate as completed lives from the parent stem. Looking at the components of the colony, towards the head half growth is expended in broadening the individual segments, towards the lower half lengthening out preponderates. At the 282nd segment the genital pit was apparent to the eye, and here an increase of breadth of segments rapidly ensued, from $\frac{21}{100}$th to $\frac{26}{100}$th of an inch. The genital pore was invariably lateral, and it was the rule to find it on the same side in contiguous segments, greatest number in such sequence 7; while the exceptional was the alternating character, apparently so conspicuous a feature in the *T. solium*, but rarely found in this species beyond two succeeding segments. In one instance only in this colony was the genital pore double, one on each side, yet malformations are far from uncommon, and with modifications of the normal textures subsequently to be detailed. With reference to the position of the genital pit in the lateral edge relative to the length of the proglottis, it occupied the centre from its first appearance to the naked eye to the 765th segment; and from this part of the colony, where the length and breadth of the individual components were equal, the orifice gradually became placed more and more below the central line, until ultimately it was seated in the lower third of the segment. This gradual transposition, however, was due to changes going on in the upper half of the zooid, having for their end the separation of the function-completed segment from the parent stem, and in no wise dependent on alterations of the generative system, so that it may be stated, that the position of the genital pit in the lateral edge in this species up to maturity of the segment is decidedly central; the changes connected with the setting free of the lowermost proglottides will be subsequently described. Other naked-eye features of the lower half of the colony were,—protrusion and tumefaction of the circumference of the genital orifice and unevenness and opacities of the flat surfaces of the segments from internal changes in the female generative system. Minor modifications of the foregoing rough details were observed in individual colonies, but the above fairly illustrate the general anatomical characters of the tapeworm as a whole.

Turning our attention to the constituents of the individual four-sided flat segment, zooid, or proglottis, we may primarily divide them into (*a*) body framework, embracing skin and parenchyma with its muscular and inorganic elements, and (*b*) contained viscera, male and female generative systems, and water-vascular canals; first entering into a description of these individually, and subsequently detailing the modifications they undergo in the progressive development from the head end of the colony downwards.

The *skin* (fig. 4) is composed of an epidermis and a corium; the former consists of a delicate imbricated epithelium layer $\frac{1}{5000}$ in. in thickness, the latter of a firm structureless elastic chitinous layer $\frac{1}{2000}$ in. thick, having on its exterior the epidermis, and on its interior a thin stratum of closely aggregated granules which form an interposing medium between it and the circular muscular coat. The skin is uniformly continuous from one segment to another; thinned out it forms a preputial fold around the penis. No calcareous granules are present in it.

Parenchyma.—Under this name I embrace the structures lying between the skin and the visceral space. The main component of this parenchyma is a soft, semi-transparent, granular, elastic, albuminoid material, very much cleared up by acetic acid or liquor potassæ, studded with so-called "calcareous corpuscles," and traversed by muscular and fibrous tissue bands. It is interposed as an uniform continuous mass between the skin and the visceral space (fig. 1, *a*; fig. 3, *a*; fig. 16, *a*) averaging $\frac{1}{50}$ in. in thickness, somewhat less in amount at the junction of the segments, and somewhat in excess at the centre, also tapering off towards the edges. Next to the granular stratum of the corium is a circular coat of muscular fibres $\frac{1}{200}$ in. thick (fig. 4, *d*); this coat for the first $\frac{1}{2000}$ in. from without inwards is free from all intercepting muscular bands, but beyond this is penetrated by fibres both longitudinal and transverse. The transverse fibres (fig. 4, *f*) radiate from near the inner surface of the corium to the boundary of the visceral space (fig. 1, *b*), the longitudinal ones are collected together in numbers averaging six, and form bands $\frac{1}{4000}$ in. in thickness (fig. 5, *a*), which traverse the segment from above downwards, and are amassed together near the skin, where they form an all but continuous layer. Permeating also the parenchyma are delicate fibrous threads; these mainly run from one lateral edge of the segment to the other in a direction wanting in muscular layers. Seated in excavations in the soft parenchyma are the granular inorganic concretions, "calcareous corpuscles." These within the range of the circular muscular coat are comparatively few in number and small, but immediately beyond it they are larger, and are very thickly set in the body substance, decreasing in amount in the centre, but increasing again towards the visceral boundary. Lying between the transverse muscular fibres they are arranged somewhat in linear series from the skin towards the visceral boundary, and the same feature pertains to the longitudinal bands. On each side of the sheath of the penis the granules are in excess, but where the one segment joins the other they are in diminished numbers. Three kinds can be observed—(1) Spherical or ovoidal nodules, average $\frac{1}{1200}$ in. in diameter, light brown in colour, composed of concentric laminæ arranged around a darker nucleus occasionally, gradually disappearing after a lengthened immersion in weak acids (1 to 10), but rapidly in stronger solutions with effervescence (fig. 6, *a*); these are greatly in the majority. (2) Ovoidal masses somewhat larger, uniform in structure, sometimes colourless, sometimes pale brown (fig. 6, *b*); some of these, like the former, disappear under acids with effervescence, others resist all acids, but are soluble in liquor potassæ, corresponding in this respect to small fat-globules and granules universally present in the parenchyma, and also within the visceral boundary in the visceral substance. (3) Angular or somewhat triangular or prismatic crystals, often aggregated in masses from six to ten (fig. 6, *c*), disappearing under acids without effervescence; these are in the minority, but apparently are more numerous in some segments than others. Hence the corpuscles may be ranged in two classes—earthy salts and organic, the former composed of carbonate of lime (majority) or phosphates (minority), the latter of fat. Considering the invariable presence of the earthy nodules and crystals in all stages of segment development and their arrangement, it is difficult to resist the inference that their use to the parasite is that of giving a firmness and stability to the body structures similar to the spicules, and like earthy accretions in some of the lower organisms; and their arrangement as isolated particles instead of continuous strands, while producing the requisite firmness, yet allows of freedom of movement of the body constituents, a feature necessary to the well-being of the parasite, as evinced by the great amount and direction of the muscular layers so conspicuous in the anatomy of this portion of the zooid.

Enclosed within the body framework of the segment are the contained viscera and water-vascular system. These are situated in a distinctly defined central compartment, separated from the soft parenchyma of the body by a thick uniform boundary wall of fibrous tissue, and occupying about $\frac{1}{3}$ of the entire proglottis and $\frac{1}{50}$ in. in thickness. As seen in a transverse section the outline of this visceral space corresponds to the body-contour, an elongated ovoid (fig. 1, *b*.), and, as exemplified in a vertical section, its diameter is uniform from above downwards, except where the segments join (fig. 3, *b*). It is supported by the transverse muscular bands, by some of the more internal longitudinal muscular bands, by delicate fibrous threads, and by strong radiating fibrous strands which connect the edges with the lateral edges of the segment. Within each lateral edge is situated the longitudinal water-vascular canal (fig. 1, *c*; fig. 2, *c*); traversing it at the lower part of each segment is the transverse or connecting water-vascular canal (fig. 2, *e*; fig. 3, *d*), immediately below which it is constricted and divided from that of the next segment by a fibrous diaphragm (fig. 3, *e*), and where the lateral edge meets the sheath of the penis there the radiating strand connecting it with the side of the segment is much thicker than elsewhere, and many of the more central fibres are lost upon the external surface of the sheath, in fact greatly assisting it in its formation. From the inside of the boundary fibrous processes pass across from side to side of the visceral space, giving a slinging support to the components of the generative systems, uterus, ovarian glands and tubes, vas deferens and testicular bodies, encircling these as in a capsule and separating them from the soft intervening substance. This substance, which fills up the space which would otherwise be left between the curved outlines of the visceral subdivisions and the internal surface of the boundary, is of a granular albuminoid character, thickly studded with small fat-granules and globules only (fig. 2, *b*; fig. 13, *b*). Laminated calcareous nodules are sparsely seated in the fibrous boundary and its main prolongations inwards, but their number is very small, and hence in this respect there is a marked contrast to the thickly set body structure environing it.

Male Generative System.—The genital orifice at the side of the segment is ovoid in shape, much more in transverse diameter than vertically; its edge is thick and tumid, and from the orifice a pit extends inwards to the depth of $\frac{1}{70}$ in., expanding vertically until the height and transverse measurements are equal. At the centre of its inner wall, on a slight oval prominence, are the external orifices of the penis and vagina, the former above the level of the latter, but in close contiguity to it (fig. 2, *g*, *h*; fig. 10). This pit is produced by an inflexion of the skin and subjacent muscular layers, and not uncommonly there is a slight depression of the external surface of the flat sides of the segment corresponding to the floor of the pit internally and caused by the tumid lips of the aperture. The skin from the genital pit is observed to form a sort of prepuce and to pass in by the side of the penis for a short distance, constituting a groove, and then to lose itself on the external surface of the organ (fig. 7, *c*); the circular muscular fibres of the body substance also curve in, and, thickened by transverse fibres and fibrous tissue, compose a sheath to the penis externally. The penis (fig. 1, *e*; fig. 2, *g*; fig. 7) in its retracted condition is a musculo-membranous elongated double cylinder, $\frac{1}{45}$ in. long by $\frac{1}{330}$ in. diameter, tapering towards the tip, but expanding at its other extremity into a globular bulb, $\frac{1}{200}$ in. thick (fig. 7, *e*, *f*).

From the genital pit it passes directly inwards towards the centre of the segment at right angles to the edge. The circumference of the organ is formed by a uniform band of circular and longitudinal muscular fibres $\frac{1}{2000}$ in. in thickness (fig. 7, *d*). Tracing it from the bulb it is continuous along the long diameter, forming the outer cylinder, to the tip; here it is seen to be reflected inwards like the inflected end of the finger of a glove and to form a second cylinder (fig. 7, *g*), $\frac{1}{1000}$ in. in diameter which passes backwards within the outer one, forming a bulbous dilatation (fig. 7, *h*) near the centre of the outer bulb, and is continued still further backwards by a convoluted tube similar in structure to itself. This convoluted tube (fig. 7, *i*) lying within the outer bulb, and in length somewhat exceeding the entire penis, perforates posteriorly the outer bulb at its centre, and is continuous with the vas deferens or spermatic tube lying within the visceral space (fig. 7, *l*; fig. 1, *g*). Between the two muscular cylinders of the penis, and filling up the otherwise vacuum, are longitudinal muscular bands (fig. 7, *k*). The internal cylinder is perforated down its centre by a narrow canal, which, constituting the aperture of the penis at its free end, passes along its long diameter and is somewhat dilated at the smaller bulb, hence is contained along the contorted tube and at length merges into the lumen of the spermatic duct; this canal from the tip of the penis to the bulb is lined by ciliated epithelium.[1] From the external surface of the outer bulb posteriorly very strong muscular bands diverge, and passing in for some distance towards the centre of the segment are lost upon the inner surface of the boundary of the visceral space. Hence, then, it will be seen that there are muscular bands of the sheath, derived from the circular and transverse layers of the body structure, which would draw the bulb of the penis towards the genital orifice and at the same time lessen in depth, and possibly obliterate, the genital pit; there are those at the bulb posteriorly, as above mentioned, which would act in the opposite direction. It would also appear from the anatomical details that the entire penis could be bodily projected to the limits of the inflected preputial fold, $\frac{1}{500}$ in., but that further protrusion would be accomplished by the evolution of the inner cylinder, and to this end the convoluted tube within the bulb and the longitudinal muscular fibres of the outer cylinder are admirably adapted; while the muscular bands lying in the body of the penis between the cylinders and stretched by the protruded

[1] Dr. J. D. Macdonald, R.N., F.R.S., informs me that he has observed the same ciliated character on a protruded penis.

organ would no less effectually retract it and assist at its inversion after copulation.

The continuation of the perforating tube of the outer bulb of the penis is for a short distance of the same thick muscular-walled structure as the convoluted tube within the bulb, and $\frac{1}{1300}$ in. in diameter, but soon this tissue thickness lessens and merges into the delicate wall of the spermatic duct. This duct or vas deferens, average diameter $\frac{1}{620}$ in., is of great length; it is seen to form a continuous close-set coiling from one side of the visceral space to the other (fig. 1, *g*) extending from the bulb of the penis to the centre of the segment, and even occasionally prolonged beyond the centre to the opposite end of the visceral space. In a longitudinal section (fig. 2, *l*) these coils are seen to be contained within a special fibrous compartment of the visceral space, passing directly inwards from the bulb and measuring $\frac{1}{125}$ in. in depth. The wall of the vas deferens is made up of very fine involuntary muscular fibre cells, forming delicate wavy longitudinal linear markings in its substance (fig. 7, *l*), and when coloured by carmine beautifully illustrating contractile tubal tissue. Between the bulb of the penis and the longitudinal water-vascular canal the coiling of the tube varies greatly in amount, but the tube and the accompanying vagina in their course towards the centre of the segment always pass together on one or other side of the water-vascular canal, never on opposite sides, and this feature of relation of the genital passages to the water-vascular system would appear to distinguish the flat surfaces of each segment into dorsal and ventral (fig. 1, *l*, *m*). The seminal duct in its meanderings gives off branches and ultimately terminates in similar divisions which form a covering to the seminal glands, or in other words, the gland structure is contained within a cæcal dilatation of the duct (fig. 8). Occasionally also the duct is varicose as from circumscribed internal distension.

The seminal glands or testicular bodies average twenty-four; they are globular, oval, pear-shaped, or crescentic in outline, and from $\frac{1}{100}$ to $\frac{1}{250}$ in. in diameter. Occasionally one may be seen close to the bulb of the penis, often one or more between the bulb and the water-vascular canal, but the general site is between the canal and the centre of the segment, though occasionally passing beyond this to the other extreme of the visceral space (fig. 1, *i′*), and their presence under these circumstances lends a clue to the comprehension of those monstrosities with a genital pit on each lateral edge. They lie within the sheath of the seminal duct, and consequently all are much upon the same plane. Occasionally they come into close contact with the distended ovarian glands and from the compression they then undergo they become crescentic in outline, forming a cap, as it were, to the female structure; there is, however, no commingling of tissue, each has its own capsule besides the fibrous sheath. The gland substance within the tubal covering is divided into component masses (fig. 8, *c*) made up of closely aggregated nuclear particles, $\frac{1}{15000}$ in. in size, resembling somewhat human lymphatic gland elements, and on isolation these nuclear particles are apparently seen to have a filamentous appendage about $\frac{1}{2000}$ in. long, tailed spermatozoa (fig. 9, *b*). I say *apparently*, for this reason, that when the gland is ruptured up to set free the particles, the encapsulating duct is equally torn and its delicate fibre-cells are separated and commingled with the gland elements, so that when observing these minute structures it is far from easy to say whether the extremely fine threads belong to the muscular fibre-cell or are filamentous processes from the sperm particle; I infer, however, the latter. It seems apparent also that the component masses of the gland are cell forms distended out with the fecundating principle.

Hence from these details we can trace an uninterrupted continuity between the sperm-producing mass and the intromittent organ, nor can any communication be observed between the male and female systems; present in each segment they are distinct.

Female Generative System.—The exact relation of the external orifice of the vagina to the penis varies with the retraction or otherwise of the male organ. Should the penis be completely withdrawn the oval-shaped vaginal orifice lies just within the fold of the prepuce underneath the tip of the organ; should partial protrusion be present, its direction is into the genital pit at right angles to the cuticle (fig. 2, *h*; fig. 7, *m*); should the evolution of the male organ be complete, then the female aperture would be situated at its base. The vagina, although opening below the penis (fig. 10, *b*), yet in its course inwards soon becomes parallel to it, but on a lower level; it crosses the longitudinal water-vascular canal with the male tube, pursuing a slightly wavy line through the middle of the visceral space, and crossed and recrossed by the coils of the spermatic canal; when nearing the centre of the segment it approaches the fibrous boundary and likewise curves downwards, and ultimately making a sudden bend on itself it joins the uterine cavity near to the junction of the middle with the lower third of the segment (fig. 1, *f*; fig. 2, *i*). The merging of its walls into the uterine walls does not ensue on that side of the cavity directed towards the edge of the segment in which the genital pit is situated, and consequently in the most convenient spot to the prior course of the vagina, but on the side of the uterus corresponding to one of the flat surfaces of the segment, and hence at right angles to its prior course (fig. 3, *f*), and apparently (at least in those instances in which I have been able to pursue its entire route from commencement to termination) on the same side as the genital tubes in relation to their crossing the water canal, furnishing an additional indication of dorsal and ventral surfaces of the zooid, and approximating in character the *Bothriocephalus latus*, the central orifices in direct line from the uterus in the latter parasite being transferred in the *T. mediocanellata* to the side, while the junction of the vagina with the uterus is the same in both. The vagina from its external aperture for the distance of $\frac{1}{825}$ in. is of the diameter of $\frac{1}{1000}$ in., has thick walls of circular and longitudinal muscular fibre, and a narrow canal lined with ciliæ (fig. 7, *m*), corresponding in the two latter details to the inner cylinder of the penis, and staining like it in depth of colour and hue on the addition of carmine or magenta. Beyond this, these thick walls merge into a thin delicate tube closely studded with very numerous black granules, which render the canal a very conspicuous and easily discerned feature in microscopic sections (fig. 12, *a*). Corresponding in site to the centre of the penis, the vagina is dilated ovally and fusiformly to $\frac{1}{400}$ in. transversely; this expansion (fig. 11) dwindles into the $\frac{1}{2000}$ in. diameter of the canal generally, which is continued until the side of the uterus is reached, where there is a second somewhat pear-shaped dilatation of $\frac{1}{450}$ in. diameter (fig. 12), from which the again contracted tube emerges to coalesce after a sudden bend with the uterine canal on a slightly prominent part of its wall. Around the muscular portion of the vagina there is a sheath formed by the inflexion of some of the fibres from the inner surface of the skin. The dark granular particles seated in the wall of the canal vary somewhat as to extent of distribution; they avoid the muscular portion, but generally commence in the succeeding dilatation, occasionally, however, but partially studding it as in figure 11; in the central course of the tube they are always present, generally also in the bulb near uterus, rarely in the short contracted channel emerging from it; they are similar to the black particles generally present in the suckers of the head of the colony.

The uterus (fig. 1, *h*; fig. 2, *k*) is a fibrous canal[1] occupying the centre of the segment from above downwards for two thirds of the distance, not approximating so closely the lower boundary of the segment as the upper, and slightly bulbous at each end, especially the lower where it is joined by the vagina. Up to the adult period of the segment it is zig-zag from above downwards, as seen in a longitudinal section, though, as seen in a vertical section (fig. 3, *g*), it does not deviate towards the front or back boundary of the visceral space; in a mature segment it is straight in either view. In shape it is oval, flattened from side to side, $\frac{1}{280}$ in. transversely by $\frac{1}{76}$ in. from before backwards (fig. 1, *h*); it is composed of fibrous tissue with an epithelial lining. Slightly from the upper, but markedly from the lower extremity, the ovarian channels radiate from it, but on each side they join it more or less horizontally. These ovarian channels (fig. 2, *m*), or smaller offshoots from the central canal, have essentially the same structure as the uterus; their length and direction varies with the position of the glands to the central canal. From the sides of the uterus the ducts are symmetrical, in number on each side amounting to about twenty-two; not uncommonly they are bifurcated and occasionally branched to three or four degrees. Equally with the prolongation of the uterine structure into the narrow communicating channels, so in reference to the limiting membrane of the ovarian glands, there is an irregular bulbous expansion retaining the gland structure or vitelline masses which lie in excavations in the granular albuminoid substance within the visceral space.

The shape of the ovarian glands varies with position, in number they amount to about forty-four in each lateral half of the segment, and in size from $\frac{1}{30}$ in. by $\frac{1}{50}$ to $\frac{1}{20}$ by $\frac{1}{100}$. Those placed between the upper and lower end of the uterus and the boundary between one segment and another are ex-

[1] According to the Sydenham translation of Kuchenmeister's 'Manual,' 2nd edition, the name designating this parasite was given it by Kuchenmeister consequent on the asserted character of the median uterus as "a continuous tube around which the sides of the worm enfold themselves. This tube, which appears to be continuous, and which I regard as a canal, induced me to call the species *T. mediocanellata*" (p. 138). In this brief description one would be led to infer that the uterus is continuous throughout the parasite, not special to each segment. If we compare the canal of this worm (fig. 2, *k*) with the sketch of the *T. solium* (Cobbold's 'Entozoa,' p. 213; Aitken's 'Prin. and Practice of Medicine,' 6th edition, p. 162), taken from Rokitansky, we shall note that the divergent characters of the two are very slight. Even on many other points there is a close approximation in anatomy between the two species, the main distinction being centred in the head.

tremely irregular in shape, more laterally they are somewhat pear-shaped, but flattened where they abut upon this boundary, while those whose discharging tubes are horizontal are narrow elongated and lobulated (fig. 2); in fact their outline from an original sphere or oval is ultimately determined by compression from within or from contiguous external structures. Their contents are closely aggregated vitelline masses or germ-cells (fig. 13, *e*), these necessarily varying in size and aspect with the degree of maturity of the zooid will be hereafter detailed.

As compared with the seminal glands the ovarian glands are differentiated from them by the nature of the encapsulating membrane, largeness of size, largeness and divergence in structure of the component elements. In both systems, however, the analogy is complete of the special element-producing masses being contained within cœcal dilatations of the conveying tubes.

Water-Vascular System.—Traversing the segment on each side, parallel to the lateral edges at the distance of $\frac{1}{15}$ in. within the visceral boundary, is a canal average $\frac{1}{50}$ in. in diameter (fig. 1, *c*). The lumen of the canal throughout the segment is far from equal and the course is marked by slight undulations. At the lower end of each segment each longitudinal canal swells out into a pear-shaped dilatation $\frac{1}{30}$ in. by $\frac{1}{75}$, globular end towards the side of the segment and narrow end continuous with the transverse water-vascular canal (fig. 2, *d*, *e*). This transverse or connecting branch, traversing the centre of the visceral space at the lower boundary of the segment, is oval in outline, straight in its course, but tapers slightly towards the centre; its lumen measures $\frac{1}{75}$ in. by $\frac{1}{200}$. Immediately below it is the fibrous diaphragm separating one segment from the other. The wall of the canals is thin, composed of delicate longitudinal and circularly arranged fibrous tissue (fig. 13, *a*), and there is no appearance of any intercepting medium to the most free passage of fluids in any direction. The longitudinal canals are not uncommonly pushed on one side by the passing genital ducts, while the inner wall is flattened and often globularly projected inwards by the distended ovarian glands which abut on it. Those of one segment are continuous with those of the preceding and succeeding ones, varying only from them in gradation of diameter; the transverse branch is special to each zooid. The globular end of the dilatation at the junction of the canals comes into close contact with the inflected body structures at the union of the segments, but apparently there is no communication between it and the external surface; this is limited to the longitudinal canals at the free end of the lowermost zooid of the colony.

Having now described the anatomical structures present in an adult segment, it becomes necessary to detail the linking of the zooids together, the head, and the modifications of each zooid in the process of development of the colony.

Bond of connection between the zooids.—The lower end of each segment is slightly expanded, while the upper end of the succeeding one is contracted and invaginated in the one above by an oblique infolding of the body wall from below upwards and continuous around the segment. This infolding implicates the skin, circular and transverse muscular fibres; some of the longitudinal muscular bands terminate in the pit left by the infolded structures, others curve around it, while the more internal pass from one segment to another. From the invaginated portion a thin fibrous band passes transversely through the body structure mapped out by the paucity of calcareous nodules on each side of it, and with a similar one within the visceral space forms a diaphragm separating one segment from the other, penetrated only by the longitudinal water-vascular canals, some of the longitudinal muscular bands, and the visceral boundary. Hence the only components which can be regarded as special to each segment are, male and female generative systems, transverse water-vascular canal; all other structures are continuous and common to the entire series.

Head of the Colony.—As before mentioned, this is somewhat square-shaped and larger than the neck, towards which it tapers. It partakes of the character of all other segments in being wider than it is thick, but in a much less ratio. On its free end there is a cross furrow, with an inflexion of the skin at the centre into a pit, and on the elevations between the furrows and the free edge of the head are the four suckers seated. Immediately below the suckers are regular transverse folds of the cuticle—the earliest differentiation of the one segment from the other, and commonly, though not necessary or constant, a large quantity of dark granular pigment is collected in the tissues between the suckers. The sucker may be defined to be a globular inflexion of the cuticle with muscular adjuncts for a special function—that of anchoring the colony. A section through it (fig. 15) reveals as follows:—The epidermis and corium of the general cuticle are continuous through it, forming the inner lining of the hollow globe (fig. 15, *d*), only that the corium is slightly thickened, firmer and more elastic, and its deeper layer strongly pigmented (*e*), the latter feature rendering the sucker a very conspicuous object in the naked-eye anatomy of the parasite. Next to the deep corium layer are two special series of muscular fibres, one radiating, the other circular; the former pass from the corium to a globular fibrous layer (fig. 15, *f*) which follows the contour of the sucker at a distance from it of $\frac{1}{200}$ in., forming a *point d'appui* for the radiating proper layer on one side, and for the insertion of muscular bands external to it on the other; the circular fibres completely encircle the sucker in concentric lines within the fibrous envelope. The diameter of the interior of the sucker averages $\frac{1}{40}$ in., of its circular orifice $\frac{1}{62}$ in., that of its fibrous capsule $\frac{1}{30}$ in. Occasionally dark pigment is also collected on the exterior of the capsule, mapping it out conspicuously from the surrounding textures, and on its exterior also (external as compared to the sucker, but actually internal as compared to the head generally) the longitudinal muscular bands common to the whole colony spread out fan-shaped, and are inserted into it (fig. 15, *h*). Hence these external bands retain the fibrous capsule in a fixed position for the special muscles to act from, the radiating bands expand the area of the hollow globe and so induce the function, the circular bands contract it, and so put a stop to the sucking action, ending in freeing the colony from the anchoring ground—the mucous lining of the small intestine; the sucker being fixed, the fibrous capsule would equally form a point for the longitudinal muscles of the colony to act from, and to move the entire series of zooids. The direction of the axis of each sucker is towards the corresponding angle of a square. Traversing the centre of the head from the neck is a horizontal fibrous layer which divides the suckers into pairs, into what may be termed a dorsal and ventral pair, the latter corresponding to the flat surface of the zooid indicated as ventral by the position of the genital ducts to the water-vascular system and the junction of vagina with uterus. This fibrous diaphragm is the termination within the head segment of the visceral boundary-wall common to the colony; when nearing the neck the walls approximate somewhat from the absence of viscera to distend them (fig. 16, *b*); in the head they are in contact, and terminate on the inner surface of the skin. Between the pairs of suckers, just beneath the skin, and corresponding in direction to the fibrous stratum (fig. 14, *f* to *g*), is the central water-vascular canal of the head, the transverse or connecting branch of the cephalic segment. Its diameter is much larger comparatively; it curves down at each end between the lateral suckers, and becomes continuous with the longitudinal canals of the colony. From it a small branch appears to encircle each sucker, which afterwards passes down to merge into the main longitudinal canal of its side, so that a section through the head immediately below the suckers reveals the cut lumen of three tubes towards each lateral edge, while one through the neck somewhat lower reveals only one (fig. 16, *c*), the smaller branches having very rapidly inosculated with the main trunk.

Progressive development of the Zooids.—The so-called neck of the tapeworm is that part of the colony from which the production of new segments starts and their subsequent development. A transverse section of it (fig. 16) shows that the body structure with the inorganic granules irregularly arranged, the fibrous boundary of the visceral space with the contained granular albuminoid material, and the water-vascular canals, are all present in it as in the mature segment, the viscera only wanting. Immediately below it fine external transverse furrowings of the skin, closely approximated, foreshadow the segmental differentiation which is more clearly indicated internally by the delicate but decided transverse fibrous diaphragm. A longitudinal section through these early segments shows the transverse water-vascular canals as small and closely approximated channels, giving at first sight the idea of this portion of the colony being more freely supplied than elsewhere, yet not exceeding in fact the number of the component segments. These transverse branches diverge more and more from each other as the segments lengthened from the head downwards, and, as well as the longitudinal canals, increase in calibre; hence we may liken this system of vessels to a ladder, the sides corresponding to the main channels, the rounds to the transverse branches, and the larger terminal ends of the sides to the open lumen of the main channels in the lowermost segment, while we must connect the smaller terminal ends of the ladder together at the top by a thickish transverse branch to coincide with the canal between the pairs of suckers. At the 160th segment from the head the visceral space is more clearly defined by the darkness of the surrounding body structure from the amassing in it of the calcareous granules, and in the lower portion of it in the midline of the segment is a collection of delicate granular material freely imbibing colouring matter—first indication of the uterus. At the 200th segment the inflection of the body structures at the junction of the zooids is well pronounced, as also the fibrous diaphragm; the lower extremity of the uterus is in the form of a globular granular mass close to the lower boundary of the segment, and curving upwards and outwards from it towards a lateral edge, but not reaching it, are linearly arranged granules similar to the uterine globule, the early stage of the vaginal canal; a collection of granules is also present near a longitudinal water-vascular canal at the site of the bulb of future penis. At the 235th segment the lower end of the uterus is clearly defined, and a broad undulating band of granules pass from it in the central line to the upper end of the segment; the outline of the genital pit is distinguishable, and the cuticle of the edge of segment corresponding to the future genital aperture is tumid; there is an irregularly undulating granular accumulation between the longitudinal water-vascular canal and the centre of the segment in the line of the site of seminal glands. From this point to the 270th segment a rapid advance in development takes place; the uterus becomes clearly defined as an undulating canal, terminating at each end in a bulbous dilatation, and containing within it spherical epithelium-like masses; the vagina, sharply outlined with dark granules in its walls, is traceable from the uterus to near the genital pit; above the level of the vagina, from the longitudinal water-vascular canal inwards, is a line of somewhat spherically amassed granules, seminal glands, and in a similar position as regards the canal, but rather close to it and arranged from above downwards in the segment, are similar masses, ovarian glands; the body of the penis is foreshadowed; the expansion at the junction of the vascular canals is well defined; the calcareous nodules are approaching linearly arranged from the circumference of the body substance to the visceral boundary. At the 282nd segment, the genital orifice being apparent to the eye, the seminal and ovarian glands are clearly defined and recognizable as such, the latter at least 100 in number on each side of the uterus and containing epithelium-like spherical cells can be turned out from the excavations in the visceral substance in which they lie; in the lower half of the segment the ovarian tubes are distinguishable, in the upper half there is still a distinct separation between the glands and the uterine channel; between the lower uterine bulb and the segmental boundary are ovarian glands, and these produce an elevation in site of the vaginal communication with the uterus to the junction of the lower with the upper two thirds of segment; from the genital pit fibres pass in forming the sheath, and within it the cylindrically arranged granules outline the penis. At the 300th segment the penis is fully formed, the seminal tube connects the testicular bodies, many of the ovarian glands have coalesced and all are connected with the uterine channel; between the upper bulbous end of uterus and the upper boundary of segment are also ovarian glands. At the 590th segment the zooid may be declared adult with full developed male and female generative systems, the latter from the uterus inclusive to its cœcal offshoots as ovarian glands filled with immature vitelline masses; the length of such a segment would be $\frac{1}{3}$ of its breadth, the anatomical details would coincide with the description already given of the several components of the segment under the respective headings. At the 690th segment, rather broader than long, fully developed ova are present in all the female passages except the vagina; the animal is mature. From this point the male generative system atrophies, and it is a difficulty to find a seminal gland, the segments markedly elongate and the uterus straightens, the lowermost prepare for separation from the parent stem.

The dropping off of the over-ripe segment, so far as the eye can trace it, consists of a gradual thinning and lengthening out of the upper half reaching its acme at the portion invaginated in the lower half of the preceding segment, until the line of junction is reduced to a mere thin film of tissue ready to give way on the slightest external force; the lower half of the segment from the genital orifice downwards undergoes but little, if any, change. More minute examination reveals that the line of rupture takes place through the fibrous diaphragm dividing the segments, a point where the calcareous granules in the body substance are in a minority, and the point where separation takes place when force is applied to the zooids in continuity and in a mature district of the colony. The transverse water-vascular canal is encroached on, and all but obliterated by the distended ovarian glands abutting on it, the ovarian follicles in the upper half coalesce by disintegration and rupture of the intervening substance so that the ripe ova lie free in the ragged space; soon the corium is the only retaining link, and ultimately this gives way, allowing the segment, with its upper half free to discharge ova and its lower half comparatively intact, to be carried out of the host with the fœcal excreta.

From these details it will be apparent that the developmental process mainly concerns the generative systems, the body structures deviating but little except in bulk in any part of the colony; also that the formation of the body structure and the separation of it into successive zooids precedes the development of the viscera. It will also be observed that the first appearance of the visceral components was in the form of amassed granules, showing their functional activity by the comparative rapid imbibition of colouring matter; and that the lower half of the segment anticipated the upper half.

The female system preceded the male in all corresponding parts, the uterus and vagina, then the ovaries, subsequently the connection of the former with the latter through the ovarian tubes; equally the bulb of the penis was first apparent in the male system, then the seminal glands, ultimately the connecting channel—the seminal duct or vas deferens. Judging from the condition of the ova fecundation must have taken place at the 590th segment, and after this the female passages become a mere receptacle for the maturing germs which evidently ripen irregularly, as evinced by the commingling of advanced and progressing ova in the same gland, and equally as well in the passages as in the site of their production.

Concerning the ova we may say that the vitelline particles in the earliest stage are spherical, oval, or irregularly compressed masses of protoplasm with a strongly defined nucleus, and average $\frac{1}{1000}$ in. in size (fig. 17, *a*). Large fat-globules stud the protoplasm, and division of the nucleus ensues until the segmentation fills the thick double-outlined wall (*b* to *e*). Separation of the components takes place into two parts, a sharply defined, firm, yet elastic, spherical body, the former nucleus, the future egg; an irregular soft surrounding granular mass (fig. 17, *f*). The spherical body gradually becomes more and more pronounced and increases in firmness, a double outlined wall is seen with radiating lines upon it and enclosing a globular body, the embryo; while the soft surrounding protoplasmic material assumes an irregular outline and wastes (*g*, *h*). The ovum darkens, the shell becomes rigid and the radiating lines more defined, the encircling soft mass disappears and the egg is matured (*i*). As such the average size is $\frac{1}{600}$ in., but varying from $\frac{1}{500}$ to $\frac{1}{660}$; shape spherical, oval, or flattened on one side from compression, or half-moon form; colour dark brown; the shell is rigid but friable, with radiating lines made up of minute pits on its inside; within the shell is a membrane which loosely retains the embryo. This outer protection is remarkably indestructible; alkalies have no effect on it except rendering its characters more clear, apparently from producing complete transparency of the surrounding albuminoid material; dilute acids (1 to 10) are innocuous; temporary immersion in strong acids leaves the shell still intact, nitric acid colouring it yellow, sulphuric acid brown; twenty-four hours' steeping in hydrochloric or sulphuric acid produces no further result, while the same period of nitric acid completely destroys every particle of the segment except the egg; some of these, however, would seem to disappear under its influence, while others effectually resist it; fire alone completes their destruction. Hence I infer that the shell is composed of a chitinous material akin to the horn-like coverings of certain insects. The embryo is spherical, with an oval offshoot occasionally to be seen from it suggestive of a head; irregular folds can be discerned on its soft exterior, and six spicules arranged in a circle in pairs; these spicules are pointed at one end and thickened and globular at the other.

Malformations.—Divergencies from the normal characters are not uncommon in these parasite colonies, the predominating forms being,—a genital pit on each side of the segment, a triangular shape of one segment from deficient development of one lateral half interposed between the usual square-shaped normal outline of segments above and below it. In one colony, in addition to the above monstrosities, were segments with a double genital pit on the one side, and for about two inches of the colony there was no external infolding of the body structures to define the limits of each segment, nor was there any internal boundary, but the genital orifices were amassed on either side in patches of from two to five, and in total amount greatly in excess of what ought to have been present over this length of the parasite.

In all these instances, whenever the genital pit was in existence, full developed internal structures corresponded to it. In those segments where the two genital orifices were on the same or opposite sides of the zooids, there was one uterine cavity, two vaginæ, and two male systems. In the triangular segment the components were normal in number, but the uterine canal was obliquely placed, the ovarian offshoots towards the base of the triangle, the lateral edge in which the genital pit was seated, were as usual, those on the opposite side were undeveloped. In the portion of colony above mentioned with so extraordinary an amount and position of genital pits, there the uterine canal extended throughout the malformed part with frequent vaginæ and spermatic tubes, full developed ova in the channels and glands. These malformations exhibited either excessive or arrested development. The uterine canal was in accord with the body structures, exhibiting no segmental division where the differentiation was not complete as regards the inflected skin and fibrous diaphragm, bearing out in these divergencies the normal development of the segments from the head downwards on the point of the body structures preceding the production and development of the viscera, and evidently also defining them.

General remarks.—The main function of the zooid is that of reproduction, all else being but subservient to it. The points of contact between the zooid and the trematode are so marked as to link the one with the other in the animal series, to cause the cestoid colony to be regarded as a compound fluke-worm. I have said nothing in the preceding pages on the existence of a nervous system, for the reason that clear anatomical details were not forthcoming to warrant the statement of its presence; yet, on the other hand, there was faint evidence of the existence of a ganglion in the head in the form of a circular nucleated cell mass in the centre beneath the suckers. But whether the presence of nerve-centres can or cannot be demonstrated there can be no question, from subjective evidence, of structures set apart for the co-ordination of certain movements and performance of certain functions; for example, a centre must be present towards the head for combining the sucker action, and also one in each segment for regulating the movements necessary in copulation, also connecting fibres must pass from one segment to another for mutual action to this end, for by analogy we must regard the zooids, although hermaphrodite, as not self-impregnating, and hence consensual action is required.

The genital pit of one segment could be brought into contact with that of another a short distance removed by the curving and bending up of the colony to one side, and by this action a transposition of their respective orifices would result, the penis of the upper segment would correspond to the vagina of the lower, and *vice versâ*, and mutual impregnation would ensue.

It is also noteworthy that the diameter of the vagina generally is $\frac{1}{2000}$ in., while the smallest size of the mature egg is $\frac{1}{600}$ in., or a relation of the latter to the former of rather more than 3 to 1; the egg is unyielding, and the delicate structure of the tube neither suggests elasticity nor contractility; in all the numerous sections I have made I have never found an egg within the canal, while the uterus is distended with them close to the point of communication; and hence I infer that the function of the vagina does not include the discharge of the ova, but is limited to the reception of the male organ, for which the muscularity near the external orifice succeeded by the dilatation is well adapted, and transference of the seminal particles. On the separation of the segment from the parent stem the uterus and ovarian passages are opened up, and a free outlet for the eggs in the upper half of the segment is thus provided, highly suggestive of the rupture of a mature spore case,[1] while those in the lower half would also escape through the rugged aperture from the muscular contraction of the freed segment soon after extrusion from the host, or be set at large by the subsequent disintegration.

The absence of an intestinal canal, and the restriction of the function of the suckers to anchoring merely, necessarily involves the absorption of nutriment by the body generally, doubtless obtained from the ingesta of the host. What, however, is the function of the water-vascular system in this parasite colony? Is it at all excretory? and if for the purpose of conveying a fluid within for respiratory purposes, then, considering the conditions under which the colony is placed in the intestine of the host, and the patulous character of the lowest and largest channels, would not the taken-in fluid from the intestinal canal officiate also for nutritive purposes? Certainly the inference is, that in this instance these tubal ramifications would act in both capacities.

What may be the especial office of this parasite colony in the scheme of the universe is a difficult problem to solve. The neglect of strict sanitary precautions in our food and drink supply is unquestionably their gain, and the loathsomeness of harbouring such creatures greatly induces to respect for preventive measures, and assists in their enforcement. There is no reason to doubt that we have the means within our own hands to rid our bodies of all chance of becoming the hosts of these zooids, and they certainly stand to us in the light of avengers of neglected laws. But whatever may be the solution, there can be no question of the remarkable adaptability of each zooid in its anatomical details to the conditions under which it is placed, and for the reproduction of its kind. Assuming that each ovarian gland produces 200 ova, each zooid would develop 8800; and on the basis that the colony consisted merely of 800 segments (that which we can count in a colony, but which is very much under the mark; for, as far as we can judge, reproduction of

[1] The *Bothriocephalus latus* (Cobbold's 'Entozoa,' p. 298) appears also to discharge the eggs "by the bursting of the over-distended uterus of the mature joint." It also is very subject to malformation, and has "a well-defined internal membrane separating the central visceral mass from the surrounding external parenchyma of the body;" points corroborating others in the natural connection between the two parasites.

segments from the neck may go on to an infinite extent) we obtain over 7,000,000 germs from one parent stem, each one capable of originating a similar colony under favorable conditions.

Addendum.—Since the above was written, in a recent post-mortem at Netley an example of *four T. mediocanellata* in the same subject was met with. For the last four and a half years the man had not been out of England, for the last one year and eleven months he had been continually in bed, with a fractured spine, and within a few days of death (when he passed a number of segments) he was not known to be infested by the parasite. The largest of the parasite colonies measured 69 inches, and was composed of about 880 segments; there were marked differences between the colonies in total length, in size of segments at corresponding points in the colonies, in the degree of regularity of the genital pit, in the more or less distinctness of the so-called neck, and in the general aspect and clearness or opacity of the zooids; the breadth of the broadest segment in one colony measured $\frac{6}{10}$ths in., as compared with $\frac{4}{10}$ths and $\frac{3}{10}$ths to $\frac{5}{10}$ths in the corresponding segments of the others; the combined features showing a marked range between individual colonies, and indicating how unreliable these points are for the differentiation of one species from the other of the same genus.

Imbedding *in* Elder Pith, *for* Cutting Sections. By C. H. Golding Bird, B.A., M.B., Lond., F.R.C.S.E., Hon. Secretary to the Medical Microscopical Society.[1]

Some time ago a paper was read before this Society explaining the modus operandi of section cutting after imbedding in wax; and taken as a whole, there is nothing in that process that is objectionable, nor is there anything wanting to allow of its being as perfect a method as possible of attaining the end for which it was designed. It is, therefore, not as a rival that I bring before your notice the process in elder pith—one known, perhaps, to some of you, though not generally adopted in this country; yet it possesses certain advantages over the one in wax, and especially

[1] Read before the Medical Microscopical Society, June 19, 1874.

so where it is a question not only of imbedding, but of using a microtome as well. If held simply in the fingers without instrumental aid, pith will yield sections in most cases equal to those obtained by the more complicated wax method, and at a cost of far less time and trouble. In the histological laboratory of Prof. Ranvier, at the Collége de France, Paris, pith is the only imbedding medium employed for all varieties of tissue, and transverse sections of spinal cord obtained through its means I recollect as peculiarly good.

The principle on which it depends is simply the swelling of the parenchymatous tissue of the dried pith in the presence of moisture, so that if placed dry in a rigid tube, as that of the microtome, with the tissue to be cut let into its centre, the addition of a little water will in the course of a few minutes so cause the pith-cells to expand, that the specimen becomes immovably fixed. Sections are then very readily cut.

Any microtome may be used for this purpose; but, as a rule, the English instruments have so large a bore that a great expenditure of pith is involved: hence I prefer the smaller instrument known as Ranvier's microtome, the one alone used in the Collége de France.[1] It carries tubes of three different sizes, and is intended to be held in the left hand of the operator, and not to be fastened to the table; and though, perhaps, a little more practice and manipulative skill are required, it has the advantage of so far yielding to the razor that the brass top need *never* be cut, while with a slight rotatory action on its own axis given to the instrument at the moment the section is being cut, so as to meet the razor halfway, as it were, the specimen may be literally "whipped off" without any of that pressure exerted upon it where a fixed microtome and a razor held in both hands are employed.

The pith used is that of the common elder, and so is found in cylindrical pieces of varying diameter. As, however, it does not matter in how many pieces it is employed, provided the specimen be well held, the thickness of the pith is not of much moment; still, to avoid trouble, it will be found that the thicker are the better.

Suppose it be required to cut a section of a tissue of about one eighth of an inch in breadth, select first a piece of pith about the size of the tube of the microtome, and of the same length as the specimen; split it longitudinally, and with the finger-nail make a small furrow on the cut surfaces of each

[1] This instrument is made by Verick, of Paris. The three tubes have the following diameters: 19 mm., 16 mm., 12 mm.

half, somewhat corresponding in depth to the thickness of the tissue to be cut; place the latter in the groove thus formed on one piece of pith, and lay the other upon it. Holding the mass between the thumb and finger, force it by gentle pressure into the microtome from above, bevelling off the extremity of the pith, if necessary, to make it enter more readily; and then with the thumb press down the whole to a level rather below that of the plate of the instrument.

The mass now, if properly fitted, should remain tolerably firmly fixed in the tube by the force of compression employed, but not so tightly as to enable one to cut sections at once; for if this be the case, the addition of water, will on expanding the pith, cause such pressure as might injure the specimen. Experience alone can suggest the exact amount of force to employ. Should the mass be too small, it must be either fitted to a still smaller tube, if there be one, or some extra slips of pith should be packed around. In either case the next step is to invert the microtome into a saucer of water; or, in the case of an instrument already fixed in the upright position, water must be poured upon it. In about three minutes the pith will have swollen sufficiently to hold the specimen firmly in its place, to have moulded itself so as to fill all inequalities or irregularities in the outline of the tissue enclosed, and to prevent effectually any chance of its revolving in the microtome when the section is being cut.

Where larger pieces of tissue are used, say of $\frac{1}{4}$ to $\frac{1}{2}$ inch in breadth, they must be packed in a manner similar to that described. Only four or more separate pieces of pith must be employed according to circumstances. Support on two sides only is often enough, especially in the case of chromic acid specimens that have undergone a full degree of hardening. Besides causing it to swell, the moistening of the pith takes away that extreme brittleness that characterises it in the dry state, and which, by causing it to break from the specimen embedded, would effectually frustrate any attempts to obtain a good section; for this reason pith, even if held in the fingers only, should be previously moistened. As in cutting wax specimens, the razor should be dipped in spirit.

To those who have never tried it this process will probably at first sight offer several objections; these, however, I hope to show may not only be overcome, but that real advantages are to be found in it. The pressure exerted upon the specimen by the swelling pith naturally first suggests itself as the principal drawback. In answer I can only say that if the tissue be hardened in the usual manner and to the usual degree, nothing is to be feared on this score; I have both used it and seen it used with very many varieties of tissue, and never found it exert a pressure that in any way was productive of harm, and this remark applies even to such structures as spinal cord, provided they have previously undergone, as stated above, the usual amount of hardening. Should it be feared in any one case that pressure, however slight, might do some injury, the specimen can previously be covered with a thin coating of wax or paraffin, and then fitted into the pith. The chance of the pith revolving in the microtome like wax has already been alluded to; this inconvenience never occurs, the friction offered by the rough pith being sufficient to prevent it. To the vegetable histologist pith is an invaluable medium; for wax *et hoc genus omne* are almost out of the question when it comes to cutting sections of leaves and the like; while, further, the pith is far less likely to blunt the razor, and is more easily moulded than carrot, to which many resort for a similar purpose.

It may further be urged that pith always involves the use of the microtome; and so it certainly does: for when simply held in the fingers, though capital results may be obtained, I fully admit that imbedding in wax is preferable if the time for it can be spared. The question, therefore, of pith *versus* wax is one chiefly of time and of comparison, and though many microscopists seem to have an innate hatred of microtomes, I ask whether it is better to adopt a process involving mechanical aid, but that costs no time to speak of, and next to no trouble, or one in which mechanical aid without special adaptation cannot, even if required, be employed, and in which time must be sacrificed in preparatory steps; and, in consequence, much trouble given? It will be seen, of course, that I am especially alluding to the rotation of the wax in the microtome, as well as to the fact that a tissue once imbedded in the machine cannot a second time be refitted without an entirely new process of casting. Such is not the case with pith. The specimen may be placed a score of times in the microtome, and after each be replaced in spirit, and as quickly refitted in the pith, if required, as on the first occasion. This suggests the combined use of pith and wax that may be employed; it has already been mentioned as protecting the specimen from all harm from pressure; but it is useful also after a wax cast has been made in the microtome. Remove the wax when sufficient sections have been cut, pare the sides, and make it more or less square, and then, on the next occasion, pack it in a little pith, and it will be found to act as efficiently as at the first casting, minus even the previous chance in its slipping round under the pressure of the razor.

I have advocated the use of pith, even, it may be, to the disparagement of the invaluable paraffin and wax. I feel, however, warranted in so doing, convinced as I am that not only unexceptional results may be easily obtained by pith, but that much valuable time may be saved.

As to the *quality* of the specimens obtained, I am almost converted to the belief that it matters but little, except in one or two cases, how or in what one imbeds, but that a good result is rather owing to the skill and ingenuity of the manipulator in each particular case. Every one upholds, naturally, the way in which he himself is accustomed to work, and rightly so; yet I question very much whether a more expeditious method of imbedding than that described is in any one's hands. Its easy portability and the complete absence of the necessity for all accessory instruments, such as tripods, spirit lamps, dishes, paper boxes, and the like, may be placed last, even though it may be least, among the advantages to be obtained by the use of elder pith.

On Apothecia *occurring in some* Scytonematous *and* Sirosiphonaceous Algæ, *in* addition *to those* previously known. By William Archer, M.R.I.A. (With Plate III.)

It is now some years since, upon examining some examples of the by no means uncommon plant, long (and by some still) accepted as algal, *Stigonema atrovirens*, Ag., that I was attracted by the peculiar enlargements of the branches, and was much interested in perceiving that this plant showed, embedded in these swellings, distinctly lichenous fructification—apothecia, as well as the so-called spermogonia. Upon searching out the literature of the subject I found from Bornet's valuable paper[1] that my discovery had been previously well known, and that my specimens fully bore out the description he gave, with the exception of the hyphæ subsequently discovered by Schwendener. Bornet, indeed, argued from the fructification which he had proved to belong to this form, that it should no longer be

[1] Bornet, "Recherches sur la Structure de *l'Ephebe pubescens*," in 'Ann. des Sci. Naturelles,' 3 sér., tom. xviii, p. 155.

accounted an alga, but relegated to the lichens as *Ephebe pubescens.*

But it occurred to me that Bornet's supposition, at the period of his writing the memoir on Ephebe, that other forms of apparent affinity (*Stigonema mamillosum, St. mammiferum* and others), being of another and different nature—that is, "algæ," whilst *E. pubescens* was a "lichen," could not be borne out.[1] It struck me, indeed, that if *Stigonema atrovirens* were no alga but a veritable lichen, that then the other *Sirosiphonaceæ* and *Scytonemaceæ*, if likewise patiently examined, *must* prove themselves of the same nature. *Stigonema mamillosum* and Sirosiphon- and Scytonema-forms, I thought, could hardly be less lichens than *Ephebe pubescens* itself; nor was I then aware that such in some cases had since Bornet's paper referred to been already actually accepted as a fact.

Having at that time more frequent opportunity of finding, amongst the Wicklow hills, the commoner representatives of the class than more recently, I then made a considerable number of gatherings and examined them as closely as I could for "apothecia." I found it a more tedious labour than might be supposed, for though I by and by found apothecia in three genera, I had to make very many hundred gatherings and examinations in order to be successful in encountering even a few "fertile" specimens; for, though possibly more frequently "fruiting" than one might suppose from that fact, the opacity and closely tufted habit of most of these forms contribute to rendering the little dark lateral tubercles usually formed by the apothecia somewhat readily overlooked, whilst they might in some forms be even passed over under a low power (the only useful way of *searching*) as merely rudimentary "branches."

It is matter of regret to me now that I did not at the time bring forward some notes upon these forms before the preparations I had made had become spoiled; and it is also a matter of still greater regret that I did not secure some drawings more in detail than the rough sketches I am able to offer. But as even a chalk drawing on a black board is better than none, so the accompanying figures (Pl. III) may serve a temporary purpose until better are forthcoming from some source, whilst the figures of the spores themselves may be accepted as accurate.

I at once assumed from the knowledge of *Ephebe pubescens*, coupled with the additional fact of having found *apothecia*

[1] Bornet, loc. cit., p. 167.

in *Scytonema, Sirosiphon, Stigonema* (*mamillosum*), that these genera and probably the whole of the *Scytonemaceæ* and *Sirosiphonaceæ* could be no longer properly accounted algæ, but should be relegated with *Ephebe* to the lichens.

But another and a different solution is put forward now-a-days by Professors de Bary and Schwendener, and those (Reess, Bornet, Treub, and others) who accept the new doctrine of the nature of lichens. It has, as is well known, been previously long supposed that, assuming the gonidia to be really organs of the lichens, these may here and there (and by no means unfrequently) become detached from the parent plant, and, under conditions unfavorable to their forming a new lichen, carry on an independent (probably abnormal) alga-like existence; and hence that many of the so-called unicellular and some of the filamentous algal growths, which may have been regarded as specifically distinct organisms, should really be expunged the list of independent plants. On the other hand, Schwendener and the new school hold that the "lichen-gonidia" *are* unicellular and filamentous algæ which vegetate within the lichen-thallus as the serviceable (assimilating) host plants of a parasitic ascomycetous fungus, the "lichen-hypha." A resumé of the whole question of the views put forward and the arguments adduced so far as the discussion has reached, both for and against, I have recently endeavoured to bring together,[1] and it is hence superfluous to attempt here to recapitulate the particulars and points of his hypothesis, except as bear upon the group immediately in question.

In his able and interesting work on the "Gonidia-forming Algal-types,"[2] and beginning with the "Phycochromaceous" series (*Nostochinæ*, Näg.) Schwendener places the *Sirosiphonaceæ* in the front rank. He justly observes they should begin the series, amongst the bluish-green filamentous forms, by reason of the well-expressed contradistinction offered by them between apex and base, also by reason of their being marked by a formation of true branches, as well as, in their higher representatives, showing an evident accession to their thickness by subsequent growth. Possessing these specialities, they at the same time, however, show an unmistakable affinity on the one hand to the *Scytonemeæ* and *Rivularieæ* in the common possession of "heterocysts" and an apical growth, and on the other to the *Nostochaceæ*, which, wanting apical growth, form a transition to the *Oscillarieæ*.

[1] 'Quart. Journal Mic. Science,' vol. xiii, n. s., p. 217; also vol. xiv, p. 115, in which places the references to the various authors are given.

[2] 'Die Algentypen der Flechtengonidien,' Basel, 1869.

Before the propounding of the new hypothesis, however, certain of these forms which, if met with without apothecia, would have been referred to the genus *Scytonema*, had been found with apothecia and new genera were formed for them by Itzigsohn and Nylander under the names *Ephebella*, Itzigsohn, and *Gonionema*, Nyl. (or *Thermutis*, Fr. ?). In fact, they seem to have regarded the "barren" and the "fertile" plant as each belonging to distinct genera, even as appertaining to different classes, that is, that the "barren" was to be accounted an "alga" and the "fertile" a "lichen."

Of course had Schwendener's view, but comparatively lately put forward, been *then* current, and had it been adopted by the discoverers of those apothecia-bearing *Sirosiphonaceæ* and *Scytonemaceæ*, the case would have been different: the *new name* would in that case have been, as I take it, understood to be applied to the "new ascomycetous parasite, within the *Sirosiphon*, or of *Scytonema*—the double names should still pass current, for, in that case, they would stand for essentially distinct things, and no less so because these occur *sometimes* living in consort and in a state of mutual physiological dependence.

The present communication, therefore, loses much of the significance it might have been at least temporarily held to possess, from not being brought out at the time the observations were made, but *after* the new theory had been not only propounded, but had gained a large amount of currency.

Nevertheless, although more superficially put forward than if I had made the matter public at the time of the observations when fresh on my mind, this will, I think, be the first record of "apothecia" being noticed in at least five fresh forms or further species referable to separate "genera" (*Scytonema*, *Sirosiphon*, *Stigonema*) in the algal point of view. If this record had been brought out at that time, indeed, it would have pointed, as I should have taken it, to the assumption that these, in place of genera of algæ, were in truth genera of lichens—not "new" lichens, but lichens not taken previously "in fruit."

With respect to *Ephebe* and *Spilonema*, Schwendener argues, that a genetic connection between the hyphæ and the gonidia is impossible. For the whole chain of gonidia leads onwards to the apical cell, by the unlimited subdivision of which new cells continuously originate, which are themselves again to be regarded as mother-cells (in some genera) of so many groups of gonidia. The assumption of a new formation of gonidia by growing-off from the hypha has no justification whatever; those who hold such a view must take refuge in the assumption of the formation of the first gonidium in the germination of the spore—a process which has not yet been observed in any lichen, and, *à priori,* never will be.

But it must be pointed out that, according to Schwendener and others, Scytonematous and Sirosiphonaceous algæ are claimed as forming "gonidia" under two distinct circumstances or conditions: they are, according to their researches, to be found in certain Lichens *either* as mere accidentally detached portions of filaments wholly surrounded and involved by the hyphæ and caught up bodily in the substance of the lichen-thallus in a completely disorderly manner, *or* they exist as perfect plants of their type as algæ, the alga-thallus quite unaltered in outward configuration, but permeated along the length of the filaments by the hyphæ, which run between the rows of green cells. When the algæ, as is assumed, are in the former way compelled to become the "gonidia-formers," it is the hyphæ (not the algæ) which must be held to control the configuration of the thallus and determine the characteristic build-up of the "lichen;" when the algæ serve in the latter way as gonidia to the intruding hyphæ, the former (not the hyphæ) retain their proper "specific" exterior, the build-up of the (algal) thallus is not externally altered and it is only a microscopic examination which would reveal anything unusual or offer any "lichenous" indication. It is as regards this latter gonidial condition that Schwendener's arguments, as to the impossibilty of the genetic relationship of the hyphæ and the young apical gonidia, by reason of the latter being formed prior to the *arrival* at the apex of the hyphal filaments, are directed, and to this condition it is that the notes here brought forward apply.

One of the most common of the *Scytonemaceæ* is the *Scytonema myochrous,* forming silky cushion-like tufts on wet rocks, when dry of mouse-colour, when wet more of an olive hue; it seems to love best a pretty constant trickle, and if the force of the little current be somewhat strong the mass may form a rather long drawn-out pad stretching down the inclination of the surface over which the little flow descends. Very often in my searchings I gathered little portions from various sites, sometimes very wet, sometimes indeed dried up by drought, and once only was I so fortunate as to find examples showing apothecia. I regret I have mislaid my rough drawing of the apothecium itself, but fig. 1 is a sketch of the spores within an ascus. The general appearance of the apothecium, however, is like that of *Sirosiphon.* The asci are accompanied by linear paraphyses; the spores are 4 in an ascus, nearly colourless, broadly elliptic, simple, with two bright corpuscles each with a minute dot in its centre immersed therein, one towards either end. Length of the spore $\frac{1}{3500}$, breadth $\frac{1}{5250}$ (figs. 1, 2).

Another *Scytonema* whose precise identity seems difficult to determine also presented apothecia. This too I found on only one occasion; the contents usually formed a thin somewhat irregular central string up the middle of a somewhat thick striated sheath, except near the apices of the "branches" (which sometimes were given off singly) in which they were thicker and quadratic (figs. 3—6). In this *Scytonema* the nearly mature apothecia were globose, smooth, shining, of a dark brownish-chocolate colour, usually placed somewhere along the length of the filament, but might be occasionally terminal (figs. 3—6). Sometimes they seemed almost to form an interruption of the continuity of the filament, or as if inserted into a special rounded excavation in it, and separated from it by a sharp line of demarcation (fig. 4). Certain of the filaments showed here and there what seemed to be agglomerations of brownish-coloured granules, which by their quantity caused a distension of the filament and an interruption of the string of contents; these I took to be incipient apothecia, judging from their position, but this is of course not certain (figs. 9—11). The more mature apothecia seemed somewhat depressed at the top where the opening occurs (fig. 6). Like the apothecia of all these forms the present are very tough and intractable, the only plan to obtain the asci separate with their spores, on account of their minuteness, being to cause them to become ejected by (very forcible) pressure. In the present instance this was of more than usual difficulty, and I was unable to press out an ascus intact to discover if it was 4- or 8- spored. I believe, however, the latter—the paraphyses—were slender linear. The separated spores themselves were somewhat readily obtained, and they are different from the preceding; here they are much longer and narrower, being of lanceolate outline, simple, colourless, with a minute dot-like corpuscle towards either end; length of spore $\frac{1}{1615}$, breadth $\frac{1}{7000}$ (fig. 8).

Coming to *Sirosiphonaceæ*, another case is offered by *S. alpinus.* Here the apothecia are smooth, but not shiny, blackish, globular, variously situated, sometimes in the axil of a branch (fig 13), sometimes along the length of the filament (fig. 12), or even terminal. Here as elsewhere it is only by pressure that the asci and spores can be ejected.

The asci, which, as elsewhere, are at first filled with a grumous granular substance (figs. 16, 17), are, when mature, 8-spored (fig. 18). Sometimes I saw asci with the contents contracted to a broadly fusiform figure, and then divided transversely, thus producing two conical bodies as if base to base (fig. 15). The paraphyses seemed to be of two lengths, the shorter about half the length of the asci, linear, pointed, the longer about one half longer than the asci, nearly twice broader than the former, with truncate end (fig. 17). The spores here are different from either of the preceding, being uniseptate, oblong, somewhat constricted at the middle opposite the septum, each end broadly rounded, colourless, each cavity showing a single central bright minute corpuscle; length $\frac{1}{1650}$, breadth $\frac{1}{3110}$ (fig. 14).

Another Sirosiphonaceous form, *S. pulvinatus* or *S. Heufleri*, showed apothecia. Here they appeared in a young condition hemispherical, when mature globose, sometimes as if somewhat produced upwards, and truncate at the opening (fig. 20). Unlike the previous, they did not appear smooth when young, but as if slightly hirsute externally (fig. 19). The clavate asci sometimes appeared somewhat truncate (fig. 21); paraphyses very inconspicuous, indeed I am more inclined to think there were none; the asci were densely crowded. Many examples showed asci filled with granular contents, the spores not yet formed. The asci when mature are 8-spored (fig. 22), the spores resembling in size and figure (but are very slightly longer than) those of the second form of *Scytonema* referred to, but differed in not having the two bright corpuscles immersed therein, and in showing a pale green colour. They are long and narrow, lanceolate, greenish; length $\frac{1}{1500}$, breadth $\frac{1}{7000}$ (fig, 23).

The last form which rewarded my search in showing apothecia was the form recorded in 'Flora Hibernica' as *Stigonema mamillosum*, but the distinction which may exist between the plant in question and *Stigonema mammiferum*, Thwaites, or *Sirosiphon coralloides*, Kütz., are not very apparent. Our plant grows in running water, attached to stones at the bottom of mountain streams. It is much more rare, seemingly, than any of the previous species; and a very pretty plant under a moderate power of the microscope, especially a young and flourishing one, with the phycochromaceous contents bright in colour and studded by the curious short and blunt branches, giving the "mammillate" appearance. The apothecia resemble those in the *Sirosiphon* above alluded to, they are blackish, globose (fig. 24); paraphyses linear, somewhat longer than the asci (fig. 25), spores 4 in an ascus, greenish, uniseptate, oblong, the septum appearing like a pale and hyaline slender transverse band, and somewhat constricted at the middle opposite the septum: the halves appear ovate, somewhat tapering to the bluntly rounded ends, each cavity showing a bright corpuscle immersed in it; length $\frac{1}{2330}''$, breadth $\frac{1}{4660}''$ (fig. 26).

In all these forms I searched as well as I could for so-called spermogonia, but was unable to detect any. These are comparatively so readily perceived in *Ephebe* (I myself found them before I was aware of Bornet's published account of them, or of the apothecia in that plant) that my non-success was the more disappointing.

Nor, after many trials by boiling in caustic potash, was I able to satisfy myself of the presence of hyphæ, as can be so readily done in *Ephebe*, as first pointed out by Schwendener; there can, however, be little reasonable doubt but that they must exist, though the seeming nascent apothecia in the second form of *Scytonema* referred to gave no indication of their presence; but that in itself would prove nothing, as the hypha cannot be seen in *Ephebe* without boiling in potash. Most probably my experiments were not conducted sufficiently long or carefully, for Bornet has shown the existence of the hyphæ in his *Spilonema paradoxum*,[1] and in his *Lichenosphæria Lenormandi*.[2]

Does it not appear somewhat inappropriate when Bornet, in describing his *Lichenosphæria Lenormandi*, makes use of the following language in the generic character:—"Thallus tenellus, ramosus, fruticulosus, fere omnino *stigonematoideus*, basi corticatus;" and as descriptive of the specific characters —"Thallus fusco-niger, tomentoso-intricatus (altitudo vix 2 millim.), ramulis divaricatis subsecundis"? For, in fact, these words simply describe the characters of *Sirosiphon divaricatus*, Kütz., which alga forms the host-plant for the peculiar lichenal parasite in question. But when he goes on to describe the apothecia, the thecæ, the spermogonia, the spores, he is giving the characters of the latter, which is the real "new species." In accordance with the new theory, besides the hyphæ, this has no thallus, the hyphæ merely push into the thallus of the *Sirosiphon*, scarcely distorting it or causing any outward alteration, beyond the occasionally exerted apothecia. If it were possible —and there is seemingly no great reason to the contrary—

[1] Dr. E. Bornet: "Description de Trois Lichens Nouveaux," 'Mémoires de la Soc. Imp. de Cherbourg,' vol. iv, p. 225, t. i, ii.

[2] Dr. E. Bornet: "Recherches sur les Gonidies des Lichens," in 'Ann. des Sci. Naturelles,' 5 sér., tome xvii (of reprint, p. 57).

that the spores of this self-same *Lichenosphæria Lenormandi* should afterwards grow upon and into another species of *Sirosiphon,* or say even into a *Scytonema,* then *some* of the "specific characters" as given, nay, even probably some of the "generic," would disappear and others take their place. It is to be granted, indeed, that on the new theory, when a *Nostoc* becomes invaded by the parasite which converts it into a *Collema,* a very considerable alteration is produced on even the outward aspect of the *Nostoc;* instead of a rounded, lobed, "blobby," and soft lump, it becomes more or less foliaceous, less watery, and more subdivided, but it is the *alga* all the time which submits to this alteration, the true *lichen* is *inside,* only evincing itself externally by its apothecia and by its action on the alga (like a *gall* causing even greater modifications on a higher plant) inciting those changes of external aspect, whilst the alga is at the same time making use of its assimilating power to do for the lichen what it cannot do itself.

There can be little doubt but that amongst these Scytonematous and Sirosiphonaceous algæ quite distinct forms occur; but, on the other hand, there can be almost as little doubt but that Kützing has vastly over-enumerated them, that many of his so-called species are not distinguishable. Now, it is hard to conceive that one and the same parasite would care very much *which* of forms so closely resembling it invaded in order to pursue its course of life. *Sirosiphon divaricatus* seems not to differ much from *S. alpinus;* it is more fructiculose, the cells in the central stems seem to occur in greater than double series; what very perceptible barrier is there to the supposition that the parasite, which invades the former to form *Lichenosphæria Lenormandi,* Bornet, might not at another time invade the latter? Would it not then fructify in the same way, show spores alike, &c.? But the parasite which does really invade the latter is not the *same* as the figure herewith will show, not to speak of the paraphyses, so prominent a feature in the latter being absent in Bornet's plant. Are these Scytonemicolous and Sirosiphonicolous parasites, then, so *extremely* particular in their choice?

See again the two Scytonemata, resembling in themselves so much and yet with "parasites" so distinct; the spores could not be confounded for a moment (see figs. 1, 2, and fig. 8). Again, see the great resemblance (but certainly not identity) between the spores in the second *Scytonema* and in *Sirosiphon pulvinatus,* algæ mutually sufficiently unlike (see figs. 8 and 23).

It might again be asked whilst the new theory is, as it were, on its trial, at what period of the life of the Scytonema or Sirosiphon does it become invaded by the parasite? At what part of the thallus does it make its entry? It must be near the base or at least not very high up, for the hypha is found growing pretty nearly *pari passu* with the growth of a branch of the alga and in the same general direction. But what is to prevent the hypha growing in the opposite direction? Might it not sometimes enter near the apex and grow backwards? Might we not sometimes expect to find hyphæ sticking out from broken-up or distorted examples of these algæ, and then revealing themselves (without the whole mass being boiled in potash) whilst on their way to invade other examples of quite the *same* alga? Or must the hypha appertaining to a particular plant have had its commencement from a spore which found its way to and alighted *somewhere* externally upon the particular *Scytonema* or *Sirosiphon*?

The account given by Itzigsohn of *Ephebella*[1] is incomplete; he met with apothecia in his species of "*Scytonema*," containing asci, but they had not as yet developed spores. The plant he had in view may certainly be said to be quite distinct from *Scytonema myochrous*. It is probable the fructification would also have been seen, if fully mature, to have been also specifically different. So too are my two forms, both in thallus and fructification. These, proceeding on the new theory, would perhaps be relegated as "new lichens" to *Ephebella*, Itzigsohn, or to *Gonionema*, Nylander; but *neither* is indentical with *Gonionema velutinum*, Nyl. (of which I have seen examples in the late Admiral Jones's Herbarium), either as regards thallus or spores. The three other forms would probably be referred as "new species" to the "lichenous" genus *Spilonema*, or that referred to *Sirosiphon pulvinatus*, wanting paraphyses, might possibly be relegated to *Lichenosphæria*.

An experimental decision of the "gonidia-question," so far as it relates to these Scytonematous and Sirosiphonaceous forms, is surrounded by not a few practical difficulties. A sowing of spores upon the algæ (as Reess did with *Nostoc*) in a natural condition could only be carried out by an observer residing in or close to the subalpine situation where these plants flourish, as they could not be "cultivated" elsewhere. In order to obtain the spores he would further have, very probably, a troublesome preliminary search, and, on the other hand, there would hardly be a certainty of the plants selected for *inoculation* being themselves previously destitute

[1] Itzigsohn, in 'Hedwigia,' 1857, p. 123.

of hyphæ or apothecia. Of course small portions from various places in a tuft of any given *alga* could be previously well examined, which, though if indeed found to represent the alga "pure and simple," would not render it absolutely conclusive that some *other* portion of the tuft might not already have been invaded by the "parasite." However, having selected some plants for experiment, they should be well inoculated with spores and portions removed from time to time for examination and experiment. If found satisfactory it would be interesting to try spores from the *same* and from *different* species (as, for instance, such as fig. 5 and fig. 26, or fig. 2 and fig. 19) in order to see the result, and whether the apparent fixity of the forms and the apparently extreme exclusiveness of the "parasites" be true or not, or ultimately whether the theory be true itself or not. Whether, for the time being, the truth of the new theory be previously assumed, or its untenability be presupposed, would matter very little, if the suitable opportunity and ready field of operations were at command of the observer. It would seem as if in this way only can either presupposition be justified or negatived.

Pending the ultimate decision at which the great lichenists who are at work on the broad question may arrive as to the true nature of these interesting plants, and pending too the discovery of the spermogonia of the forms here referred to as assisting to throw a light on their mutual affinities and relative position, I may well leave to more skilled hands the desultory notes brought forward in this communication touching their general bearing and ultimate application as regards one of the most interesting and problematic botanical questions of the day.

OBSERVATIONS *on the* DEVELOPMENT *of the* CEPHALOPODA. By E. RAY LANKESTER, M.A., Fellow of Exeter College, Oxford. (With Plates IV and V.)

WORKERS are so numerous and so energetic at the present moment in the field of embryology that a man who has there gathered something new after some labour, must hasten to publish his results, even though in a rough and incomplete form, if he would have them serve as contributions to knowledge. Elaborate illustrations require for their preparation so great a lapse of time that before they can be issued some other observer has likely enough given to the scientific public the very information they were intended to convey. It is for this reason that I am about to give a brief notice, accompanied by rough sketches, of a few points of interest in the developmental phenomena of the Cephalopoda which I ascertained during the spring of 1872, and subsequently during that of 1874 at Naples. On the last occasion I had the advantage of making use of the arrangements carried out by my friend Anton Dohrn, in the Zoological Station and Aquarium now so well known. I have already given a very brief notice of the facts which I had observed in 1872, in the 'Proceedings of the Royal Society,' 1874, and in the 'Annals and Mag. Nat. History,' 1873. With regard to these two notices I have only to say here, that the statement contained in them to the effect that the primitive mouth aborts and a secondary mouth develops, is due to an error of interpretation. Where not otherwise indicated, the following remarks refer to *Loligo*.

The Ovarian ovum.—I do not give here diagrams of any of my drawings illustrating this phase, since they will shortly be published in full. The egg-capsule is at first composed of a single layer of cells, a second inner capsule or inner layer of cells then forms, which grows out in a series of folds into the space occupied by the egg-cell. From the cells forming the mucous-like epithelium of these folds albuminous matter is continually added to the egg, and at a certain stage of its development the cells themselves continually proliferate or bud off from the folds into the egg-mass. The folds of the inner capsule are accompanied by blood-vessels, and it is their arrangement which gives the basket-work pattern to the surface of the ovarian eggs of *Sepia*, *Loligo*, and *Octopus*. The outer capsule is smooth. The inner capsule atrophies as its cells are absorbed into the ripening egg. Finally, the outer capsule bursts, allowing the egg to escape, leaving behind it a stalked calyx.

The formation of the Blastoderm.—The egg on its escape from the calyx appears to have a very delicate pellicle or chorion on its surface, and there is a trace sometimes of the arrangement of the chief folds of the inner egg-capsule, which probably *have a causal relation to the form subsequently taken by the chief cleavage segments.* The egg-shell which forms round the egg in the oviduct has a small hole at the narrower pole, which may be called a micropyle. Gelatinous material is subsequently added to this shell, embedding many eggs in the case of *Loligo*. I have not observed anything relative to the time of fertilisation. In *Octopus* the egg-shell is elongated and stalked (fig. 2). Within it may be seen the areolated pellicle (*ce*) which the egg brought with it from the egg-capsule. When the egg arrives in the oviduct the germinal vesicle has disappeared; it is still present in full-sized ovarian eggs. The egg is now a homogeneous mass of granular elements with a small amount of intergranular plasma. The granules are modified cells of the inner egg-capsule; the plasma chiefly formative material. The further process of development begins with a *segregation* of formative matter and the breaking up or *segmentation* of this segregated matter—involving to a certain extent the unsegregated major portion of the egg. A small cap of formative matter segregates to the narrower pole of the egg. It presents no nucleus, persistently, though a nucleus *may* appear in it at the first. The cleavage has been described by Kölliker; it does not proceed so regularly as he has represented. A nucleus is to be seen in each of the first cleavage segments, but in the later segments there is great irregularity in this matter. I have most fully satisfied myself that temporarily many of the segmentation products are devoid of nucleus.

Passing over the details of this process, which I reserve for another occasion, I proceed to the period when the "cleavage" may be said to have ceased. A cap of cells at one pole of the egg is the result of the cleavage of the mass segregated at this point (see fig. 1*). I call these cells "klastoplasts." They are not sharply cut off from the rest of the egg, nor is the segregated mass from the cleavage of which they arise, but the group of klastoplasts thin out at the periphery as it does, and become fused with the undifferentiated yelk. They extend their area at first by growth along lines corresponding to the chief radial grooves of the cleavage, a marginal cell of the cap of klastoplasts at such a point growing by accretion of formative material (continued segregation) and then breaking into two. When the cap of klastoplasts has spread one third over the egg, its marginal cells grow by a regular increase in size and consequent fission, taking place equally all round the margin. But before the superficial extension of the cap of klastoplasts has commenced there appear in a deeper stratum of yelk pellucid nuclei, at first arranged in a circle around the cap of klastoplasts, as I have figured them in 'Annals and Mag. Nat. Hist.,' April, 1873. These pellucid nuclei are of the same nature as the nuclei of cleavage segments. They might be taken for them, and no doubt the first series of them are physiologically convertible with such nuclei. I believe in the eggs of *Loligo* there may be according to season an increase of nucleated cleavage segments, or, on the other hand, of these bodies, they being reciprocally vicarious within small limits. But the feature in which they differ from the nuclei of cleavage segments is this, that no area becomes segmented around them. They make their appearance in great numbers *near to* but not *at* the surface of the egg-mass, extending first in ring-like series in advance of the margin of the klastoplasts, but subsequently appearing indiscriminately over all parts of the egg. The klastoplasts as they advance to the parts where these bodies already lie grow over them, occupying a higher stratum of the egg. These nucleus-like bodies can be observed in all their stages of development in living eggs, and I have satisfied myself that they commence as minute points, gradually increasing in size like other free-formed nuclei. I distinguish them as "autoplasts." They form a very large part of the blastoderm, but the whole of its superficial layer (epiblast) is formed by cells which can be directly traced by successive fissions to the first cleavage segments of the patch of formative material segregated to the cleavage-pole of the egg, in fact are klastoplasts.

The autoplasts (*a*) are seen in fig. 1, where the overlying klastoplasts are omitted.

The autoplasts continue to develop near the surface of the yelk in *Loligo* until a very late stage of development. In fact, they are present in the contents of the reduced remnant of the yelk-sac possessed by the young *Loligo* at birth.

Comparatively little importance would attach to the autoplasts if we did not know their subsequent development. They become branching, stellate, and fusiform cells, underlying the klastoplasts, and form that contractile tissue which gives to the yelk-sac its *power of rhythmical contraction* (similar to the embryonic contractile sac of *Limax*, &c.), the observation of which I have previously recorded. They also form a large portion of the deeper substance of the embryo itself. In fig. 1, K, the klastoplasts from near the upper pole of the egg are represented. In A we have a group of autoplasts, of which *ef* and *cd* are seen to possess filamentous prolongations. They are seen *through* the living transparent klastoplasts. Acetic acid gives the result seen in A′. The klastoplasts *s s* come to view as a continuous pavement, whilst the autoplasts shrink and granulate and show nucleus and nucleolus. When the autoplasts *first* appear, they, like the nuclei of cleavage segments, are not affected by dilute acids.

The autoplasts of *Loligo*, of which I have just been speaking, are represented by similar bodies in *Sepia*. In *Octopus* the autoplasts are present but differ, since they are more irregularly disposed, often of large size, and present radiating granular fringes (fig. 2 A). They are often placed deeply in the yelk.

These autoplasts are not such exceptional bodies to-day as they were three years ago when I first found them.[1] Götte has found that the deep yelk of the hen's egg continues to segment after the superficial cleavage products have been formed. Balfour has found the yelk of the Shark's egg full of bodies comparable to these autoplasts. I believe that the matter may be viewed thus:—a first segregation furnishes the patch of formative matter at one pole, which subsequently exhibits the phenomena of cleavage. Independently of and subsequently to this, segregation of formative matter goes on at numberless points of the egg's surface or deeply. These latter segregations are the autoplasts. If it be asked "whence comes the 'formative matter' and what is it?" the reply is, "from the original egg-cell and spermatic filaments, and it continually nourishes itself on the interfused particles of food-yelk resulting from the metamorphosed cells of the inner egg-capsule of the ovarian egg."

The first appearance of the Pen-sac in Loligo and Octopus.—In the October number of this Journal for 1874 I have given a diagrammatic figure of a section of part of an embryo of *Loligo* at a time when the rudiments of various organs—eyes, ears, mouth, foot, rectum—first appear. The Pen-sac is there shown to originate as a space enclosed by the upgrowth of a ring-like wall of the mantle, the margins of which close together by later growth. This and earlier as well as later stages I have studied by means of sections of embryos hardened both in osmic and in picric acids, and subsequently mounted and now preserved in Canada balsam. I have also made sections of *Octopus* at corresponding periods, and I find that in this genus the fossa for the pen-sac is developed, but its margins never close in. It is evanescent. The same is true of Argonauta.

First appearance of the alimentary canal.—Passing over many matters of much interest which I have not space now to describe or illustrate, I shall here draw attention to the first appearance of the alimentary canal, and at the same time point to some facts bearing on the question of "germ-layers" in the Cephalopoda.

From the mouth a pharynx, with salivary glands as

[1] At one time I thought it possible that the autoplasts were vacuoles, or rather, drops of differentiated albuminous matter, *into* which the klastoplasts sent outgrowths or budded off cells. This view is taken by Oellacher with reference to certain vacuole-like bodies occupied by one or two cells in the egg of osseous fish. On testing this hypothesis I have rejected it, for there is no doubt that the autoplasts are dense, solid bodies like the nuclei of cleavage segments, and no such hypothesis accounts for the autoplasts of Octopus.

diverticula, and an œsophagus, grow towards the mantle-pole of the embryo, where at a late period of development the tu e so formed meets and unites with another portion of the alimentary canal which has developed on the opposite (the aboral) face of the embryo. The first appearance of this part of the alimentary canal is seen in a small tubercle in living embryos, at a period when the pen-sac is still open, which tubercle lies between the two rudimentary gill-buds, a little in advance of them. A cavity develops itself in this tubercle, which was mistaken by Kölliker for the aortic heart. A section at this period gives the result shown in fig. 3. Three layers of cells can readily be distinguished in this section as in that figured by me in the October number. That marked *ep* is the epidermic layer or epiblast obviously enough. The mass of rounded cells below it may be called "mesoblast," since from it the muscles and skeletal elements are developed; and by *splitting*, it gives rise to *primitive vascular* spaces (see fig. 5, *pv*), and an inner and outer group of mesoblastic elements, corresponding to "Darmfaserplatt" and "Hautfaserplatt." Below this we come to a single layer of large fusiform cells separated by membranous intervals, *ym*. Is this the hypoblast? Leaving aside speculative discussions the question is, Does the epithelium of the middle portion of the alimentary canal develop from this layer? The cell-layer in question separates the embryo from the enclosed mass of yelk, and extends everywhere over the yelk (into the yelk-sac as within the embryonic area). It persists as long as there is a trace of yelk. Owsjannikow describes such a layer of cells in *Corregonus*, which he does *not* regard as hypoblast. The section fig. 3 shows the space *al*, the first trace of this portion of the alimentary canal, lined by cells, which appear to be independent of the layer *ym*. They seem rather to be a differentiated layer of the mass which is marked *mes*. A somewhat later stage (fig. 4) shows also no connection between the cell-layer *ym* and the lining cells of the cavity *al*. It moreover gives evidence of a passage of yelk-granules *y* into the cavity *al*, which may be due to a natural inflection of the layer *ym* (in which case the cells lining the cavity *al* might be continuous with the layer *ym*), or, as is more probable, may be due to rupture of the layer *ym* in the preparation of the section.

Transverse sections, of which one is figured in fig. 6, corresponding in age to the vertical antero-posterior section fig. 4, equally fail to establish the derivation of the intestinal epithelium from the layer *ym*. Fig. 7 represents a section which comes nearest to such a condition as would render it possible to suppose that at one particular point not hit off in the other sections, the layer *ym* is continued into the cavity *al*, and has there given rise to its lining cells. This I think is very unlikely, from the examination of numerous sections, though such a derivation at an earlier stage of development than those examined by me is not impossible. The layer *ym* agrees in the character of its cells with the Vertebrate hypoblast (chick).

In fig. 5 the ink-sac is seen to commence as a diverticulum, *is*, of the primitive chamber of the anal tubercle. The epithelium of the chamber of the anal tubercle is in close contact from the earliest stage at which I have seen it, with the epidermic epithelium, and much later at this point the anus breaks through. I have *not* found, what might be looked for on *à priori* grounds (comparison with other molluscs), that the chamber of the anal tubercle is formed by an invagination from the external layer at this point.

In pursuing further the development of the chamber which makes its appearance in the anal tubercle, I found it to increase considerably in size, and to extend around the base of the internal yelk, where subsequently, by steps which I have not followed out so as to enable me to epitomise them without reference to many figures, it effects a junction with the œsophageal tube which has pushed its way down on the opposite (oral) face of the embryo. The whole of the alimentary canal, with the exception of pharynx and œsophagus, develops by the growth of this primitive chamber of the anal tubercle. In fig. 8 (a little later in age than fig. 5) a diagrammatic transverse section is given, showing the first development of the liver as two cœca extending from it, so as to embrace the cavity occupied by the internal yelk. In fig. 9 a vertical right-and-left section of a somewhat older embryo is given, showing the upward (towards the head) growth of the hepatic processes or diverticula. They increase rapidly in size, and finally come to occupy exactly the space once filled by all the posterior portion of the internal yelk (that is, the yelk enclosed by the embryo as distinguished from that held in the appended yelk-sac.)

Blood-vessels and lymph spaces.—In the various sections (more than 150 in number) of embryo *Loligo, Sepia,* and *Octopus* which I have made, the development of the hearts, large vessels, and of the renal organ have been followed out. At the present time I will merely point to the fact, that the mass of cells, *mes*, which we may for convenience call "mesoblast," splits at various points (see fig. 5, fig. 6, fig. 7, fig. 8, *pv* and *v*), giving rise to a disconnected series of spaces, which are the representatives of a *cœlom* or *body-cavity*. From these and their walls are subsequently developed the hæmolymph spaces and hæmolymph vessels and circulatory organs.

Development of the Otocysts.—I have previously stated (*loc. cit.*) that the auditory capsules commence as open invaginations of the epidermic layer; I now give a sketch of one of these invaginations (fig. 17) at a period when the eye and pen-sac are also in the condition of open chambers formed by the epidermic layer.

Development of the Eye.—The facts to be stated under this head were brought forward in Section D of the British Association at its meeting in Belfast in last August. The eye first appears as an oval ridge, enclosing an area of the same form on the surface of the embryo. It is seen in a side view in fig. 12, from above in fig. 13, and in diagrammatic section in fig. 15. The walls of this oval area close in above, leaving a minute scar at their point of juncture. They are seen not quite closed in fig. 14 from above, and in section in fig. 16. This phase of the development of the Dibranchiate Cephalopod's eye corresponds with the permanent condition in the Tetrabranchiate Nautilus. In fig. 10 the eye is seen at a later period and not in strictly median section. A mass of mesoblastic cells are now seen to intervene between the primitive optic chamber and the epidermic layer of cells. The lining of the primitive optic chamber is entirely derived from the epidermic layer from which it was invaginated. The cells of the posterior wall and sides become developed into retinal elements, the cells of the anterior wall are differently modified, becoming changed into a "ciliary body," which as Hensen has described is applied to the sides of the lens and contains muscular elements. In the section fig. 18 these cells are seen, *ci*. The section is not precisely through the median plane; such a section of the same eye is given in fig. 19. The first commencement of the *lens* is seen in these figures. It is apparently a viscid, somewhat fibrous structure, totally devoid of cellular elements. It is formed *entirely within* the primitive optic chamber, and at first depends as a short cylindrical rod from the middle point of the anterior wall of that chamber, that is to say, from the point at which the chamber finally closed up. It grows subsequently by the deposition of concentric layers of a horny material around this core. No cells appear to be immediately concerned in effecting this deposition, and it must be looked upon as an organic concretion, formed from the liquid contained in the primitive optic chamber.

From the wall of mesoblast covered with epiblast lying in front of the primitive optic chamber after its complete invagination a circular fold arises, which is seen in the various sections as two flaps marked IF. They are the iris-folds, and grow so far towards each other as to partially enclose an anterior optic chamber, *soc*. The complete enclosure of this chamber is effected by further overgrowths of tegumentary folds, the corneal folds, sometimes called a coalesced eyelid, which in many cephalopods completely unite in the middle point, so as to form a cornea-like structure, or else leave a minute aperture. This tegumentary overgrowth is seen in the section fig. 21, marked TO.

The layer of mesoblastic cells lying between the anterior wall of cells of the primitive optic chamber, and the posterior wall of epidermic cells (*pe*) of the secondary optic chamber, is large and obvious enough in the younger stages of the eye, but it subsequently becomes atrophied, and in later stages, figs. 20, 21, is a mere structureless membrane.

From its position in the eye of the adult *Sepia* and *Loligo* it appears that the lens must in a later stage of development than that drawn in fig. 21 push its way through the median anterior area of the primitive optic chamber and project into the secondary or anterior optic chamber, where the iridian folds lie closely upon it. Whether the cellular structures at this point are actually broken through, or whether they merely atrophy and become adherent to the anterior portion of the lens, I am not at present able to say.

The important result, however, is that the lens is embraced equatorially by the remarkable ciliary body developed from the anterior lining cells of the primitive optic chamber.

The identity of the Dibranchiate eye within its earliest phase with the adult Tetrabranchiate eye is an important result from one point of view. Not less interesting is the total divergence of the cuttle-fish's eye from that of the vertebrates in its mode of development, whilst presenting so much identity in mechanical arrangements with it. One cannot leave these facts without pointing, moreover, to the close agreement in development and early structure of the Cephalod's *primitive* and the Vertebrate's *secondary* optic vesicle, respectively retina and lens.

The White Body.—The remarkable history of this body was also the subject of a communication which I made to the British Association at Belfast. In the epitome (*loc. cit.*) of my earlier observations on *Loligo* I stated that below each eye a deep and long invagination of the epidermic layer occurred, giving rise to a pair of nerve-ganglia. I have since found that these supposed nerve-ganglia are the 'white bodies' observed in connection with the eye and optic ganglia in adult Cephalopoda Dibranchiata. I am disposed to regard them as atrophied or suppressed nerve-ganglia, probably representing the cephalic ganglia of other Mollusca which develop in the same position and essentially in the same way as do these white bodies. In fig. 10 the section passes below the eye, through one of these invaginations which is still open. I have numerous drawings of the invagination in the living state at this and later periods. The mass of tissue (NG) at the base of the optic invagination has the form of a peduncle. It does not, I believe, arise in connection with the optic invagination, but is formed in the mesoblastic mass of cells. It is this optic peduncle which gives rise to the great optic ganglion on each side, and to the other smaller ganglionic masses.

In fig. 11, a section at a later period is seen where the nerve-ganglion has grown to a large size and is definitely dividing itself into lobes. The white body (WB) is seen still of large size. In living specimens of about this age the "white bodies" are very obvious and prominent, whilst the large mass of the optic peduncles present two very distinct lobes on each side. In subsequent growth the mass (NG) encroaches upon the white body, which becomes flattened out, and no longer advances in growth at the same rate as the surrounding parts. Sections at this period lead to the conclusion that *the optic ganglion is nourished at the expense of the material of the White Body*, and finally when the eye and optic ganglion have attained an enormous proportionate size in comparison with the other parts of the embryo (a few days before birth), the white body is seen as a much reduced mass of embryonic (undifferentiated) cells occupying the angle between the eye and optic ganglion and squeezed into obscurity between the two. A full series of drawings from the sections are needed to elucidate the history of the white body and optic ganglion, but the examples selected from a large number in my possession, viz., figs. 10 and 11, must suffice for the present.

That so important an organ as the cerebral or super-œsophageal ganglion of Mollusca should disappear or become rudimentary in Cephalopoda must appear somewhat startling, as also the fact that nerve ganglia should develop from so-called mesoblast. This last phenomenon I believe to be in accordance with the general law which relegates to "mesoblast" various structures originally either epiblastic or hypoblastic, when the tendency to direct development can be served. Thus the notochord of Vertebrates, perhaps originally hypoblastic, has become mesoblastic, as have also Wolffian and Mullerian ducts. The former phenomenon, the atrophy of the cephalic nerve-ganglia, is in accordance with a principle which appears to have a wide application in embryology, namely, the transference or attraction of nutrition.

On the Chromatological Relations *of* Spongilla fluviatilis. By H. C. Sorby, F.R.S., &c.

I had long been anxious to examine fresh specimens of *Spongilla*, since the old and dry specimens which I had studied clearly showed that the colouring matters had been greatly altered. At length, through the kindness of Mr. E. Ray Lankester, I was able to investigate the subject in a perfectly satisfactory manner. I had previously examined some of the marine sponges growing on the coast of Devonshire, which are often of a fine orange colour, but sometimes have a well-marked green tint. In the natural state these did not show the band in the red characteristic of chlorophyll; and, though when dried and digested in carbon bisulphide the solution contained a small quantity of chlorophyll, yet I could not be certain that it had not been derived from a small portion of some alga accidentally enclosed in the sponge. The exact nature of the green substance is therefore still open to some slight doubt. The chief coloured constituent was an orange substance soluble in carbon bisulphide, which, when so dissolved, had a pink tint in dilute solution. The spectrum had no detached narrow absorption-bands, but cut off the whole of the green and blue, and when diluted allowed the blue to pass rather more readily than the green. I was not able to distinguish any difference between it and an orange-coloured substance found in the eggs of the crab, but it would be premature to say that the two are identical. There is also an orange colouring matter found in the soft parts of some species of *Cardium*, closely allied, though not identical, with these, and on the whole it seems pretty clear that the coloured compounds found in some marine sponges are either identical with or closely related to those met with in animals, and unlike those occurring in the higher classes of plants. Fungi do, indeed, sometimes contain very closely allied substances, but I do not yet know any certainly identical. At all events, when looked upon from a chromatological point of view, such sponges are closely related to animals, or to those plants which, like them, are nourished by complex chemical compounds, and cannot be supported by merely mineral substances, like the more perfect plants.

In my paper on comparative vegetable chromatology[1] I have shown that the highest classes of plants contain the following essential constituents, soluble in carbon bisulphide:

Blue chlorophyll.
Yellow chlorophyll.
Orange xanthophyll.
Xanthophyll.
Yellow xanthophyll.
Lichnoxanthine.

The constituents soluble in water are—

Various kinds of *chrysophyll.*
Various kinds of *erythrophyll,* which are often absent, and are not essential.

Now, when I came to examine the fresh specimens of *Spongilla fluviatilis* I soon found that it contained all the above-named substances soluble in carbon bisulphide, and a small quantity of a yellow substance soluble in water, very similar to, if not identical with, one met with in many fungi, differing from the chrysophyll of the higher plants in not being made deeper coloured by alkalies or paler by acids. The other constituents appear to be absolutely identical with those in plants, and I cannot agree with Mr. Ray Lankester in looking upon the chlorophyll as a distinct substance.[2]

There being thus very little *qualitative* difference between the *Spongilla* and the highest classes of plants, it became necessary to ascertain whether there was any well-marked *quantitative* difference, which would point to a closer relation to one class than to another. The plan of analysis adopted was to separate the various coloured constituents, wherever possible, and to determine their relative amounts by measuring in long test tubes of equal diameter the lengths of the columns of liquid giving the same intensity of absorption with equal illumination, and, when the constituents could not be separated, to compare the respective absorption-bands in the same manner. I may here say that, unlike what

[1] 'Proceed. Roy. Soc.,' 1873, vol. xxi, p. 442.

[2] See his paper in the 'Journal of Anatomy and Physiology,' vol. iv, p. 119.

occurs in the case of many plants, the yellow chorophyll cannot be partially separated from the blue chlorophyll, both in the case of *Spongilla* and of many lichens. The relative quantity of the xanthophyll and yellow xanthophyll was determined by the difference in the position of the absorption-bands, and also by the greater or less amount of the blue product of the oxidization of yellow xanthophyll, formed when the solution was treated with a little hydrochloric acid and nitrite of potash. The lichnoxanthine was estimated from the final residue after the xanthrophylls had been destroyed and rendered colourless by the slow action of citric acid and nitrite of potash. By such means and others described in my paper on comparative vegetal chromatology I have been able to draw up a table, giving, with approximate accuracy, the relative amounts of the different coloured constituents; but on the present occasion it seems to me better not to give the percentages, and to express the general results by means of the following symbols:—

A relatively large quantity	*
A relatively moderate quantity	+
A relatively small quantity	•
A relatively mere trace	·

Table of the relative amounts of the various coloured constituents insoluble in water, that of the xanthophyll being taken as nearly constant.

	Blue chlorophyll.	Yellow chlorophyll.	Orange xanthophyll.	Xanthophyll.	Yellow xanthophyll.	Lichnothanthine sol. in CS_2.	Lichnothanthine insol. in CS_2.
Highest classes of plants—							
Development perfect . . .	*	+	*	+	*	·	
Development incomplete . . .	+	·	*	*	+	•	
Development still more incomplete .	·		•	*	+	•	
Spongilla—							
The external deep green part . .	*	•	•	*	+	•	
The internal yellowest part . .	+	•	·	*	+	+	
Lichens—							
Very green species	*	•	•	*	+	+	+
Less green species	+	·	·	*	+	*	*
Algæ—							
The green group :	*	*	+	*	+	·	
The red group	+		·	*		•	

Now, although this table must be looked upon as merely a first attempt, yet the results appear to be sufficiently definite to warrant some provisional general conclusions.

The *Spongilla* is distinguished from the red group of algæ, not only by the absence of the characteristic red and purple substances soluble in water, but by the presence in the *Spongilla* of yellow chlorophyll and yellow xanthophyll, which are absent in the case of red algæ. There is a closer relation between *Spongilla* and the green algæ, but they contain a relatively far larger quantity of yellow chlorophyll. The lichens differ from the sponge, not only in containing a relatively larger amount of the lichnoxanthine soluble in carbon bisulphide, but are still more distinguished by containing much of the modification insoluble in that reagent, which is absent in the case of the sponge. In other respects there is a very strong analogy, since the relative amounts of blue and yellow chlorophyll and of the three different kinds of xanthophyll are almost identical. Comparing the most perfectly developed specimens of the *Spongilla* and of the highest classes of plants, it is distinguished by containing relatively less yellow chlorophyll, less yellow xanthophyll, and very much less orange xanthophyll, and by the presence of an entirely different yellow substance soluble in water, perhaps identical with one found in many fungi. The *Spongilla* is, however, completely distinguished from fungi by the chlorophyll and xanthophyll, which are quite absent from them. Though there is thus no *qualitative* difference between the colouring matters found in *Spongilla* and in plants, yet in none of the above-named classes do they agree in their exact *quantitative* relations. Some light is, however, thrown on the subject by examining the change in their relative proportions in variously developed individual leaves or portions of the *Spongilla*. By comparing together the more or less completely developed leaves in large buds, I find that in their earliest stage of growth, before being exposed to anything more than the weak light which penetrates through the exterior leaves, the amount of blue chlorophyll is very small, and that of the yellow chlorophyll relatively smaller than normal. In comparison with the amount of xanthophyll, there is an abnormally small quantity of orange xanthophyll and yellow xanthophyll, but greater of lichnoxanthine. As development proceeds the orange xanthophyll soon attains its normal proportion, whilst the other yellow constituents have undergone very little relative change and the amount of chlorophyll is but slightly increased, that of the yellow chlorophyll being still abnormally less in relation to that of the blue chlorophyll. The result of these changes is that at one particular state of partial development the ratio between the blue and yellow chlorophyll and that between all the different yellow constituents are the same in the leaves of the highest plants as in the well-developed *Spongilla*, but even then there is not perfect agreement, since it contains a far greater amount of the chlorophyll in relation to the other constituents. Comparing together different portions of the *Spongilla* in the same manner, we arrive at similar results. The lower portions, where exposed to feeble light, are far yellower than the exterior, and contain relatively much less chlorophyll, and the proportion between the yellow and blue chlorophyll is even less than normal. There is also a relatively less amount of orange xanthophyll, but an increased quantity of lichnoxanthine and of the yellow substance soluble in water which resembles that met with in fungi. It will thus be seen that the lower and less perfectly developed portions of the *Spongilla* approximate in these chromatological characters to the lowest type of normal lichens, and present us with a lower type of colouring than any that I have yet been able to find in the most rudimentary leaves of the higher classes of plants.

Taking, then, all the above facts into consideration, it will be seen that the colouring of *Spongilla* is not exactly the same as that of any particular class of plants, but represents more or less closely a special low type, in which development has proceeded according to a somewhat different law up to a point reached at an early period of their growth by the leaves of the highest classes of plants. The analogy between these facts and those met with in structural embryology will not fail to strike every one, and I cannot but think that the further study of such questions will throw much light on many interesting problems.

Seeing also that the less developed portions of *Spongilla* lose more and more of the characters of the higher plants and approximate more to the type of fungi, one need not be so much surprised that in some species of sponge the plant-character is altogether lost, and that the type of colouring closely approximates to that of fungi and of the lower animals. It would, I think, be therefore well worthy of study to ascertain whether low animal forms which, like *Spongilla*, contain chlorophyll, have when exposed to light the power of decomposing carbonic acid and supporting themselves to some extent as plants, and at the same time have the power of supporting themselves by means of organic particles conveyed into their interior by the water circulating about or through them. If so, they would be animals to some extent capable of plant-like growth, and would thus be the reverse of those plants which have lately attracted so much attention on account of their being able to partially support themselves by means of complex animal food, which they can digest and absorb like the most perfect classes of animals.

On the Classification *of the* Animal Kingdom.[1] By Professor Huxley, Sec. R.S.

Linnæus defines the object of classification as follows:—"Methodus, anima scientiæ, indigitat, primo intuitu, quodcunque corpus naturale, ut hoc corpus dicat pro-prium suum nomen, et hoc nomen quæcumque de nominato corpore beneficio seculi innotuere, ut sic in summa confusione rerum apparenti, summus conspiciatur Naturæ ordo." (*Systema Naturæ*, ed. 12, p. 13.)

With the same general conception of classificatory method as Linnæus, Cuvier saw the importance of an exhaustive analysis of the adult structure of animals, and his classification is an attempt to enunciate the facts of structure thus determined, in a series of propositions, of which the most general constitute the definitions of the largest, and the most special, the definitions of the smallest, groups.

Von Baer showed that our knowledge of animal structure is imperfect unless we know the developmental stages through which that structure has passed; and since the publication of his 'Entwickelungs-Geschichte der Thiere,' no philosophical naturalist has neglected embryological facts in forming a classification.

Darwin, by laying a novel and solid foundation for the theory of Evolution, introduced a new element into Taxonomy. If a species, like an individual, is the product of a process of development, its mode of evolution must be taken into account in determining its likeness or unlikeness to other species; and thus "phylogeny" becomes not less important than embryogeny to the taxonomist. But while the logical value of phylogeny must be fully admitted, it is to be recollected that, in the present state of science,

[1] Read at the Linnean Society, Dec. 4, 1874. Reprinted from 'Nature' with the permission of the author.

absolutely nothing is positively known respecting the phylogeny of any of the larger groups of animals. Valuable and important as phylogenic speculations are, as guides to, and suggestions of, investigation, they are pure hypotheses incapable of any objective test; and there is no little danger of introducing confusions into science by mixing up such hypotheses with Taxonomy, which should be a precise and logical arrangement of verifiable facts.

The present essay is an attempt to classify the known facts of animal structure, including the development of that structure, without reference to phylogeny, and, therefore, to form a classification of the animal kingdom which will hold good however much phylogenic speculations may vary.

Animals are primarily divisible into those in which the body is not differentiated into histogenetic cells (PROTOZOA), and those in which the body becomes differentiated into such cells (METAZOA of Haeckel).

I. The PROTOZOA are again divisible into two groups: 1, the Monera (Haeckel, in which the body contains no nucleus; and 2, the Endoplastica, in which the body contains one or more nuclei. Among these, the *Infusoria ciliata* and *flagellata* (*Noctiluca,* e.g.), while not forsaking the general type of the single cell, attain a considerable complexity of organisation, presenting a parallel to what happens among the unicellular Fungi and Algæ (e. g., *Mucor, Vaucheria, Caulerpa*).

II. The METAZOA are distinguishable, in the first place, into those which develop an alimentary cavity—a process which is accompanied by the differentiation of the body wall into, at fewest, two layers, an epiblast and a hypoblast (*Gastreæ* of Haeckel), and those in which no alimentary cavity is ever formed.

Among the Gastreæ, there are some in which the gastrula or primitive sac with a double wall open at one end, retains this primitive opening throughout life—as the egestive aperture; numerous ingestive apertures being developed in the lateral walls of the gastrula—whence these may be termed *Polystomata.* This group comprehends the *Spongida* or *Porifera.* All other Gastreæ are *Monostomata,* that is to say, the gastrula develops but one ingestive aperture. The case of compound organisms in which new gastrulæ are produced by gemmation is of course not a real exception to this rule.

In some Monostomata the primitive aperture becomes the permanent mouth of the animal (*Archæostomata*).

This division includes two groups, the members of each of which respectively are very closely allied:—1. The Cœlenterata. 2. The Scolecimorpha. Under the latter head are included the *Turbellaria*, the *Nematoidea*, the *Trematoda*, the *Hirudinea*, the *Oligochæta*, and probably the *Rotifera* and *Gephyrea*. In all the other Monostomata the primitive opening of the gastrula, whatever its fate, does not become the mouth, but the latter is produced by a secondary perforation of the body wall. In these *Deuterostomata* there is a perivisceral cavity distinct from the alimentary canal, but this perivisceral cavity is produced in different ways.

1. A perivisceral cavity is formed by diverticula of the alimentary canal, which become shut off from the latter (*Enterocœla*). The researches of Alexander Agassiz and of Metschnikoff have shown that, not only the ambulacral vessels, but the perivisceral cavity of the *Echinodermata*, are produced in this manner; a fact which may be interpreted as indicating an affinity with the Cœlenterates (though it must not be forgotten that the dendrocœle *Turbellaria* and many *Trematoda* are truly "cœlenterate"), but does not in the least interfere with the fundamental resemblance of these animals to the worms. Kowalewsky has shown that the perivisceral cavity of the anomalous *Sagitta* is formed in the same way, and the researches of Metschnikoff appear to indicate that something of the same kind takes place in *Balanoglossus*.

2. A perivisceral cavity is formed by the splitting of the mesoblast (*Schizocœla*). This appears to be the case in all ordinary *Mollusca*, in all the polychætous *Annelida*, of which the *Mollusca* are little more than oligomerous modifications, and in all the *Arthropoda*.

It remains to be seen whether the *Brachiopoda* and the *Polyzoa* belong to this or the preceding division.

3. A perivisceral cavity is formed neither from diverticula of the alimentary canal nor by the splitting of the mesoblast, but by an outgrowth or invagination of the outer wall of the body (*Epicœla*). The *Tunicata* are in this case, the atrial cavity in them being formed by invagination of the epiblast.

Amphioxus, which so closely resembles an Ascidian in its development, has a perivisceral cavity which essentially corresponds with the atrium of the Ascidian, though it is formed in a somewhat different manner. One of the most striking peculiarities in the structure of *Amphioxus* is the fact that the body wall (which obviously answers to the somatopleure of one of the higher *Vertebrata*, and incloses a "pleuro-peritoneal" cavity, in the walls of which the generative organs are developed) covers the branchial apertures, so that the latter open into the "pleuro-peritoneal" cavity. This occurs in no other vertebrated animal. Kowalewsky has proved that this very exceptional structure results from the development of the somatopleure as a lamina which grows out from the sides of the body and eventually becomes united with its fellow in the middle ventral line, leaving only the so-called "respiratory pore" open. Stieda has mentioned the existence of the raphé in the position of the line of union in the adult animal. Rathke described two "abdominal canals" in *Amphioxus;* and Johannes Müller, and more recently Stieda, have described and figured these canals. However, Rathke's canals have no existence, and what have been taken for them are simply passages or semi-canals between the proper ventral wall of the abdomen and the incurved edges of two ridges developed at the junction of the ventral with the lateral faces of the body, which extend from behind the abdominal pore where they nearly meet, to the sides of the mouth. Doubtless, the ova which Kowalewsky saw pass out of the mouth had entered into these semi-canals when they left the body by the abdominal pore, and were conveyed by them to the oral region. The ventral integument, between the ventrolateral laminæ, is folded, as Stieda has indicated, into numerous close-set, longitudinal plaits which have been mistaken for muscular fibres, and the grooves between these plaits are occupied by epidermic cells, so that, in transverse sections the interspaces between the plaits have the appearance of glandular cœca. This plaited organ appears to represent the Wolffian duct of the higher *Vertebrata,* which, in accordance with the generally embryonic character of *Amphioxus,* retains its primitive form of an open groove. The somatopleure of *Amphioxus,* therefore, resembles that of ordinary *Vertebrata* in giving rise to a Wolffian duct by invagination of its inner surface. But the Wolffian duct does not become converted into a tube, and its dorsal or axial wall unites with its fellow in the raphé of the ventral boundary of the perivisceral cavity.

In all the higher *Vertebrata* of which the development has yet been traced, the "pleuro-peritoneal" or pervisceral cavity arises by an apparent splitting of the mesoblast, which splitting, however, does not extend beyond the hinder portion of the branchial region. But, in many *Vertebrata* (e. g., *Holocephali, Ganoidei, Teleostei, Amphibia*) a process of the integument grows out from the region of the hyoidean arch, and forms an operculum covering the gill-cleft. In the frog, as is well known, this opercular membrane is very large, and unites with the body wall posteriorly, leaving only a "respiratory pore" on the left side, during the later periods of the tadpole's life. Here is a structure homologous with the splanchnopleure of *Amphioxus;* while, in the thoraco-abdominal region, the splanchnopleure appears to arise by splitting of the mesoblast. Considering what takes place in *Amphioxus*, the question arises whether the "splitting" of the mesoblast in the *Vertebrata* may not have a different meaning from the apparently similar process in the *Arthropoda, Annelida,* and *Mollusca;* and whether the pericardium, pleura, and peritoneum are not parts of the epiblast, as the atrial tunic is of the epiblast of the ascidians. Further investigation must determine this point. In the meanwhile, on the assumption that the pleuro-peritoneal" cavity of the *Vertebrata* is a virtual involution of the epiblast, the peritoneal aperture of fishes becomes truly homologous with the "respiratory pore" of *Amphioxus;* and the Wolffian ducts and their prolongations, with the Müllerian ducts, are, as Gegenbaur has already suggested, of the same nature as the segmental organs of worms.

The division of METAZOA without an alimentary cavity is established provisionally, for the *Cestoidea* and *Acanthocephala*, in which no trace of a digestive cavity has ever been detected. It is quite possible that the ordinary view that these are Gastreæ modified by parasitism is correct. On the other hand, the cases of the Nematoid worms and of the *Trematoda* show that the most complete parasitism does not necessarily involve the abortion of the alimentary cavity, and it must be admitted to be possible that a primitive Gregarinform parasite might become multicellular and might develep reproductive and other organs, without finding any advantage in an alimentary canal. A purely objective classification wil recognise both these possibilities and leave the question open.

REVIEW.

Stricker's Manual of Histology.[1]

The third volume of the translation of Stricker's histology completes this important work. The subjects comprised in this volume are the organs of sense and the uterine organs; and it concludes with a chapter on the development of the simple tissues by Professor Stricker. As we have spoken pretty fully of the merits and defects of the other volumes, it may be sufficient to say that both are represented in this portion of the work. The special merits of Dr. Stricker's plan certainly predominate in the chapters on the sense-organs, since few histologists who are not specialists could undertake these difficult themes. Of the elaborateness with which they are treated, it may give some notion if we state that no less than ten writers treat of the eye and its appendages. Professor Max Schultze's admirable monograph on the retina (probably one of the last publications of that lamented histologist) will doubtless be classical, but that of Rollett on the cornea is quite worthy to stand beside it; and we should especially recommend English histological students carefully to work through the elaborate description of this structure, which has been, ever since Toynbee discovered the corneal corpuscles, so favorite an object with the German anatomists. It has certainly contributed far more than many more important organs to the progress of histology both normal and pathological.

The concluding chapter on development of tissues gives an account, necessarily condensed, of the formation of tissues as traced from early embryonic life. The chief moral which we feel inclined to draw from the caution with which Stricker expresses himself is that it is very unsafe to found upon the relations of the embryonic layers, such wide generalisations in

[1] 'Manual of Human and Comparative Histology.' Edited by S. Stricker. Vol. III. Translated by Henry Power. The New Sydenham Society. London, 1873.

biology and even in pathology as we have seen put forward of late years. As regards pathological relations in man, we are building upon a very uncertain basis if we rest upon the distinction of germinal layers, since it is, as Professor Stricker remarks, still doubtful whether the laminæ of the mammalian ovum correspond (especially the middle) with the three distinguished by Remak in the fowl's embryo. And yet we have had whole classes of new formations and special types of disease founded upon the distinctness of the layers of Remak.

This chapter has been looked for with some interest on this ground also—that it was to contain the omitted or deferred theme of striated muscle; and Professor Stricker has redeemed his promise by giving a short sketch, partly descriptive, partly critical, of the subject. The descriptive portion would have been made much clearer by figures, and this is also true of the critical portion, but the latter suffers under the more serious, though quite unavoidable defect of failing to take into account the researches, since published, of Engelmann and Schäfer, since these have given a new aspect to the question in dispute. In fact, the "commotion in the doctrine of muscle," which induced the editor to defer the consideration of this subject as long as possible, can hardly be said to have subsided in time to make a completely satisfactory article at all possible.

We must, in conclusion, congratulate the translator upon the successful completion of his arduous task, and as we have in the former volumes not always agreed with his interpretation of some of the crabbed German idioms, we may also be allowed to bear our tribute to the care with which this volume has been edited and translated. It has also the advantage of a very full and excellent index, which strikes us as being, in plan and execution, decidedly superior to that in the German edition.

THE LATE DR. LANKESTER.

We have to record, with much regret, the death of Dr. Edwin Lankester, one of the founders of this Journal, and for many years one of its Editors.

Dr. Lankester was born April 23rd, 1814, at Melton, Suffolk, and was educated at Woodbridge, where he was articled to the late Mr. Samuel Gissing, surgeon. He studied medicine from 1834 till 1837 at University College, London, and in the latter year was made a Member of the College of Surgeons and Licentiate of the Apothecaries' Society. In 1839, he visited the Continent, and graduated at Heidelberg; in 1843, he became Lecturer on Materia Medica and Botany at the School of Medicine adjoining St. George's Hospital; in 1844, he was appointed Secretary to the Ray Society; and, in 1845, was elected Fellow of the Royal Society. In 1850, he was appointed Professor of Natural History in New College, London; in 1851, he received the degree of LL.D. from Amherst, United States. In 1853, he became Lecturer on Anatomy and Physiology at the Grosvenor Place School of Medicine; in 1858, Superintendent of the Food Collection at the South Kensington Museum; in 1859, President of the Microscopical Society; in 1862, Examiner in Botany to the Science and Art Department at South Kensington; and was elected Coroner for Central Middlesex in 1862. Dr. Lankester contributed to the 'Naturalist,' 'Annals of Natural History,' to the 'Pharmaceutical Journal,' the 'Penny Cyclopædia,' and 'Reports of the British Association for the Advancement of Science.' He wrote 'Natural History of Plants Yielding Food,' and 'Memorials of John Ray,' published in 1845; edited the 'Correspondence of John Ray,' in 1846; contributed the article "Rotifera" to the 'Cyclopædia of Anatomy and Physiology,' and a "Report on the Progress of Organic Chemistry," to the 'Companion to the British Almanack,' in 1847; published a translation of Schleiden's 'Principles of Scientific Botany' in 1849; and contributed reviews of medical works and papers on Natural History to the 'Athenæum.' Dr. Lankester became joint-editor of the 'Quarterly Journal of Microscopical Science' in 1853; he also wrote "Botany" in Hughes's 'Reading Lessons,' and, by the command of Her Majesty, edited the 'Natural History of Dee-side.' He translated Küchenmeister's 'Animal Parasites' in 1859; contributed, in conjunction with Dr. Letheby, the article on Sanitary Science to the 'Encyclopædia Britannica' in 1859; published 'Half-hours with the Microscope;' 'Two Addresses to the Microscopical Society of London;' 'A Guide to the Food Collection at the South Kensington Museum;' 'A Course of Lectures on Food,' and 'A Course of 'Lectures on the Uses of Animals;' and has delivered Lectures on Natural History, and its various branches, at the Royal Institution; several courses on Physiology and Botany at the London Institution; and several courses on Botany before the Royal Botanical Society of London. As Coroner for Middlesex, he has published nine "Annual Reports" in the 'Proceedings of the Social Science Association;' and, as Medical Officer of Health for St. James's, Westminster, has published sixteen "Annual Reports." In 1866, he edited the 'Journal of Social Science,' and published a small work entitled 'Cholera; What it is, and how to prevent it.' In 1867, appeared 'Good Food; What it is, and how to get it;' in 1868, 'Vegetable Physiology;' in 1869, a 'School Manual of Health;' and, in 1870, 'What shall we Teach? or Physiology in Schools,' besides several articles in 'Nature,' on scientific subjects.

He continued his literary and professional career until 1862, when, on a vacancy occurring in the office of Coroner for Central Middlesex, Dr. Lankester was elected to the post by a majority of the constituency, and was also chosen by the Vestry of St. James's, Westminster, as their officer of health. He died on October 30th, 1874, at Margate, and was buried at Hampstead.

We are here chiefly concerned with Dr. Lankester's connection with this Journal, which was long and intimate. The 'Quarterly Journal of Microscopical Science' first appeared in 1853, under the joint editorship of Dr. Lankester and Mr. Busk, partly as the organ of the Microscopical Society of London, partly as an independent journal. This arrangement was continued till 1868, when the connection with the Society was severed. Mr. Busk retired, and the Journal was thenceforward carried on by Dr. Lankester and his son, Mr. Ray Lankester, till the retirement of the former in 1871. For nearly twenty years, therefore, Dr. Lankester was actively concerned in the editorship. The first publisher was Mr. Highley, and on his retirement from business the Journal passed into the hands of its present proprietors. From the first the editors were able to congratulate themselves on a degree of success very noticeable in the case of a purely scientific journal: the first number went through no less than four editions, and a position was rapidly obtained which the Journal has never since, we hope, been suffered to lose.

Without at all pretending to offer any general estimate of the value of Dr. Lankester's scientific work, there are a few points in this career of incessant and varied activity to which we should like to draw attention.

In the first place, we cannot but notice how much of Dr. Lankester's cultivation must have been the fruit of his own mental activity and energy. The scientific education of a medical student in 1834 can have been little more than what he gave himself, and it is no small credit to the scientific workers of the last generation that their intellectual equipment was so complete as it was. In Dr. Lankester's case the strongest stimulus was present in an ardent love of his subject. He was a born naturalist, and not one of those whose love of natural objects is fostered by academical ambition, or merely a part of a general sympathy with intellectual pursuits. But while he was a diligent observer of nature he was also something beyond, and was never satisfied with the easy standard of excellence set up by those who pride themselves on the name of field naturalists. Much of his literary energy was spent in endeavouring to lead such persons, and especially the amateur users of the microscope, to a higher conception of the dignity of their favorite pursuit. This was clearly one of the chief ends which, as joint-editor of this Journal, he set before him, and, we may be permitted now to say, with considerable success. A considerable part of the Journal was set apart for translations and abstracts of foreign memoirs, chiefly German, and English naturalists were thus made acquainted with the important results arrived at by Schwann and his successors, which had hardly then produced their full effect on English science. The translations of German textbooks, which occupy a large space in the list of Dr. Lankester's writings, served an analogous purpose.

It is impossible, however, to read the long catalogue of these works without perceiving that the production of many of them must have been due to circumstances rather than to predilection; and while the energy which they display is astonishing, we may be tempted to regret that so much of it was thus directed. We cannot doubt that Dr. Lankester himself might sometimes have found more congenial occupation in strictly scientific research; it does not therefore follow that he would have been employed more usefully for mankind than he was in the unostentatious task of popularising science. The work of diffusing knowledge has to be done, and rightly appeared to the leaders of the "useful knowledge" school—sometimes now spoken of with unmerited contempt—as of national or more than national importance. It was certainly done by Dr. Lankester with zeal and success. His wide popular sympathies made him intolerant of anything like scientific exclusiveness, and his genial disposition made him always a welcome teacher, especially to the young. Wherever he went he was actively engaged in awakening an interest in natural science, and he adopted, with characteristic enthusiasm, the then novel appliances of fern-cases, aquaria, and other aids to the study of natural history, which have since proved by no means unimportant instruments both in popular education and in scientific research. As a popular lecturer he was very successful, being fortunate in a singularly pleasant voice and a happy gift of natural eloquence. Many now living can look back to Dr. Lankester's teachings as among their first encouragements to the study of nature, and among these it may be not unbecoming to mention his eldest son, now one of the editors of this Journal, whom he early imbued with his own love for natural objects, in whose intellectual development he was most deeply interested, and who perpetuates in a more instructed generation the scientific zeal of his father. Whatever he has achieved may be fairly set down as due to the teaching and example of Dr. Edwin Lankester.

J. F. P.

NOTES AND MEMORANDA.

Rotation of Embryo-Lymnæus.—May I be permitted to call the attention of the readers of the 'Quart. Journ. of Micros. Science' to a fact which has escaped Mr. E. Ray Lankester's notice in his valuable and interesting inquiry into the "Development of the Pond-Snail"?

If Mr. Ray Lankester will do me the favour to turn to vol. ii (1854), page 92, 'Quarterly Journal of Microscopical Science,' he will find that I mention the existence of cilia, and ascribe the rotatory motion of the embryo to the same. I may add that my observations were made with a *Ross's half-inch*, and therefore I am at a loss to account for the fact he mentions, that these cilia "have entirely escaped the attention of M. Lereboullet."—Jabez Hogg.

Different Diatoms on the same Stipes.—In the 'Quarterly Journal of Microscopical Science' for July, 1873, page 313, in the report of the proceedings of the Dublin Microscopical Club, Mr. Archer has made some remarks on two distinct diatoms presenting the appearance of being on the same stipes as bearing on Dr. Bastian's views. Therein he alludes to a paper of mine reprinted in the 'Monthly Microscopical Journal' from the 'Proceedings of the Boston Society of Natural History,' February 9th, 1870. In my paper I stated that I found *Gomphonema capitatum* and *constrictum* both growing upon the same stipes. Mr. F. Kitton, who examined my specimens, confirmed my observation, and yet Mr. Archer thinks we are both of us mistaken, and that the occurrence of these apparently distinct forms upon one stipes was accidental, and that I have failed to distinguish between actual organic genetic relationship and accidental superposition. It was on November 6th, 1867, that I first found these two species growing upon the same stipes, and showed them to several persons, competent observers with the microscope. I also sent specimens to Dr. Arnott, as mentioned in my original paper. They, unfortunately, did not arrive until after his death, and, at my request, they were sent to the Quekett Club, where Mr. Kitton saw them and confirmed my discovery. On the stipes of the *Gomphonema* was *Achnanthes minutissima*, F. T. K., after the manner described by Mr. Archer. On October 17th, 1869, as well as at other times during the preceding summer, I made collections at the same place exhibiting the same phenomenon; and on the 14th of September, 1871, in a small stream about two miles from the first locality, I found *Gomphonema constrictum, capitatum, acuminatum*, and *cristatum*, all growing upon the same stipes along with intermediate forms. I took care to deposit specimens of my first gathering in the cabinet of the American Microscopical Society, New York, and, as I have said, the specimens I sent Dr. Arnott are in the collection of the Quekett Club in London; but as probably Mr. Archer will not have an opportunity of visiting either of these collections, I will gladly send him specimens, as I have secured a plentiful supply of all of my gatherings.

I have in hand the microscopical work of the Geological Survey of New Hampshire, and I hope diatomists will be glad to hear that I shall ere long go to press with a report on the so-called "infusorial deposits" of that state. I shall be at all times glad to furnish specimens to those interested, and, in fact, would be pleased to have the names and addresses of every one interested in the *Diatomaceæ*.

A. Mead Edwards, M.D.

Newark, New Jersey, U.S.

Coloured Rings of Crystals as seen through the Microscope.—Dr. W. H. Stone has communicated to the Physical Society an account of an arrangement for exhibiting the coloured rings of uniaxial and biaxial crystals in a common microscope.

The author was not aware that any arrangement had been hitherto supplied to the ordinary microscope other than an extra top to the eyepiece, containing a supplementary stage and an analyser. This could only be considered a clumsy expedient.

The objects to be attained were clearly two—first, to transmit the rays at considerable obliquity through the plate of crystals; secondly, to gather these up, and form a real image within the tube of the microscope. Amici had accomplished this by a special combination of lenses which bears his name; it might, however, be done simply by placing a screwed diaphragm on the end of the upper draw-tube within the body of the microscope. The screw should be that ordinarily used for object-glasses. To this an object-glass of long focus was fitted, and another of higher magnifying power in the usual place. The whole body was then drawn out and adjusted to a telescopic focus on a distant object. The lower objective formed the object-glass of the telescope and the inner objective with the Huyghenian eyepiece a compound ocular.

On reinserting the body thus arranged, and illuminating the crystal on the stage with convergent light by means of a condenser, the rings and brushes could be perfectly seen. The whole double series of rings on a biaxial crystal of carbonate of lead was thus shown.

The condenser used was a "kettle-drum" of two plano-convex lenses. The objective on the nozzle of the microscope was a two thirds of Ross; that within the draw-tube a three-inch objective of the same maker.—*Philosophical Magazine.*

Globigerina Ooze.—From the Cape, as far south as our station in lat. 46° 16′, the Challenger found no depth greater than 1900 fathoms, and the bottom was in every case "Globigerina ooze;" that is to say, it consisted of little else than the shells of Globigerina, whole, or more or less broken up, with a small proportion of the shells of Pulvinulina and of Orbulina, and the spines and tests of radiolarians and fragments of the spicules of sponges.

Mr. Murray has been paying the closest attention since the time of our departure to the question of the origin of this calcareous formation, which is of so great interest and importance on account of its anomalous character and its enormous extension. Very early in the voyage he formed the opinion that all the organisms entering into its composition at the bottom are dead, and that all of them live abundantly at the surface and at intermediate depths over the Globigerina ooze area, the ooze being formed by the subsiding of these shells to the bottom after death.

This is by no means a new view. It was advocated by the late Prof. Bailey, of West Point, shortly after the discovery, by means of Lieut. Broke's ingenious sounding instrument, that such a formation had a wide extension in the Atlantic. Johannes Müller, Count Pourtales, Krohn, and Max-Schultze, observed Globigerina and Orbulina living on the surface; and Ernst Haeckel, in his important work upon the Radiolaria, remarks that "we often find upon, and carried along by the floating pieces of seaweed which are so frequently met with in all seas, foraminifera as well as other animal forms which habitually live at the bottom. However, setting aside these accidental instances, certain foraminifera, particularly in their younger stages, occur in some localities so constantly and in such numbers, floating on the surface of the sea, that the suspicion seems justifiable that they possess, at all events, at a certain period of their existence, a pelagic mode of life, differing in this respect from most of the remainder of their class. Thus Müller often found in the contents of the surface-net off the coast of France the young of Rotalia, but more particularly Globigerinæ and Orbulinæ, the two latter frequently covered with fine calcareous tubes, prolongations of the borders of the fine pores through which the pseudogradia protrude through the shell. I took similar Globigerinæ and Orbulinæ almost daily in a fine net at Messina, often in great numbers, particularly in February. Often the shell was covered with a whole forest of extremely long and delicate calcareous tubes projecting from all sides, and probably contributing essentially to enable these little animals to float below the surface of the water by increasing their surface greatly, and consequently their friction against the water, and rendering it more difficult for them to sink."[1] In 1865 and 1866 two papers were read by Major Owen, F.L.S., before the Linnean Society, "On the Surface Fauna of Mid-Ocean." In these communications the author stated that he had taken foraminifera of the genera Globigerina and Pulvinulina, living in a tow-net on the surface, at many stations in the Indian and Atlantic Oceans. He describes the special forms of these genera which were most common, and gave an interesting account of their habits, proposing for a family which should include Globigerina, with Orbulina as a subgenus, and Pulvinulina, the name Colymbitæ, from the circumstance that, like the Radiolaria, these foraminifera are found on the surface after sunset, "diving" to some depth beneath it during the heat of the day. Our colleague, Mr. Gwyn Jeffreys, chiefly on the strength of Major Owen's papers, maintained that certain foraminifera were surface animals, in opposition to Dr. Carpenter and myself.[2] I had formed and expressed a very strong opinion on the matter. It seemed to me that the evidence was conclusive that the foraminifera which formed the Globigerina ooze lived on the bottom, and that the occurrence of individuals on the surface was accidental and exceptional; but after going into the thing carefully, and considering the mass of evidence which has been accumulated by Mr. Murray, I now admit that I was in error; and I agree with him that it may be taken as proved that all the materials of such deposits, with the ex-

[1] 'Die Radiolarien.' Eine Monographie von Dr. Ernst Haeckel. Berlin, 1862, pp. 166, 167.

[2] Mr. Jeffreys desires to record his dissent from this conclusion, since (from his own observations, as well as those of Major Owen and Lieut. Palmer) he believes Globigerina to be exclusively an oceanic foraminifera inhabiting only the superficial stratum of the sea. (Preliminary Report of the Scientific Exploration of the Deep Sea, 'Proceedings of the Royal Society,' No. 121, page 443.)

ception, of course, of the remains of animals which we now know to live at the bottom at all depths, which occur in the deposit as foreign bodies, are derived from the surface.

Mr. Murray has combined with a careful examination of the soundings a constant use of the tow-net, usually at the surface, but also at depths of from ten to one hundred fathoms; and he finds the closest relation to exist between the surface fauna of any particular locality and the deposit which is taking place at the bottom. In all seas, from the equator to the polar ice, the tow-net contains Globigerinæ. They are more abundant and of a larger size in warmer seas; several varieties, attaining a large size and presenting marked varietal characters, are found in the intertropical area of the Atlantic. In the latitude of Kerguelen they are less numerous and smaller, while further south they are still more dwarfed, and only one variety, the typical *Globigerina bulloides,* is represented. The living Globigerinæ from the tow-net are singularly different in appearance from the dead shells we find at the bottom. The shell is clear and transparent, and each of the pores which penetrate it is surrounded by a raised crest, the crest round adjacent powers coalescing into a roughly hexagonal network, so that the pores appear to lie at the bottom of a hexagonal pit. At each angle of this hexagon the crest gives off a delicate flexible calcareous spine, which is sometimes four or five times the diameter of the shell in length. The spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long transparent needles crossing one another in different directions have a very beautiful effect. The smaller inner chambers of the shell are entirely filled with an orange-yellow granular sarcode; and the large terminal chamber usually contains only a small irregular mass, or two or three small masses run together, of the same yellow sarcode stuck against one side, the remainder of the chamber being empty. No definite arrangement and no approach to structure was observed in the sarcode, and no differentiation, with the exception of round bright yellow oil-globules, very much like those found in some of the radiolarians, which are scattered apparently irregularly in the sarcode. We never have been able to detect in any of the large number of Globigerinæ which we have examined the least trace of pseudopodia, or any extension in any form of the sarcode beyond the shell.

Major Owen (*op. cit.*) has referred the Globigerina with spines to a distinct species, under the name of *G. hirsuta.* I am inclined rather to believe that all Globigerinæ are to a greater or less degree spiny when the shell has attained its full development. In specimens taken with the tow-net the spines are very usually absent; but that is probably on account of their extreme tenuity; they are broken off by the slightest touch. In fresh examples from the surface, the dots indicating the origin of the lost spines may almost always be made out with a high power. There are never spines on the Globigerinæ from the bottom, even in the shallowest water. Two or three very marked varieties of Globigerina occur; but I certainly do not think that the characters of any of them can be regarded as of specific value.

The wonderfully pure calcareous formation in the neighbourhood of Prince Edward Island and the Crozets consists almost solely of *Globigerina bulloides.*

According to our present experience the deposit of Globigerina ooze is limited to water of a certain depth, the extreme limit of the pure characteristic formation being placed at a depth of somewhere about 2250 fathoms. Crossing from these shallow regions occupied by the ooze into deeper soundings, we find universally that the calcareous formation gradually passes into and is finally replaced by an extremely fine pure clay, which occupies, speaking generally, all depths below 2500 fathoms, and consists almost entirely of a silicate of the red oxide of iron and alumina. The transition is very slow, and extends over several hundred fathoms of increasing depth; the shells gradually lose their sharpness of outline and assume a kind of "rotten" look and a brownish colour, and become more and more mixed with a fine amorphous red-brown powder, which increases steadily in proportion until the lime has almost entirely disappeared. This brown matter is in the finest possible state of subdivision, so fine that when, after sifting it to separate any organisms it might contain, we put it into jars to settle, it remained for days in suspension, giving the water very much the appearance and colour of chocolate.[1]

Orbulina.—There is still a good deal of obscurity about the nature of *Orbulina universa,* an organism which occurs in some places in large proportion in the Globigerina ooze. The shell of Orbulina is spherical, usually about ·5 millimètre in diameter, but it is found of all smaller sizes. The texture of the mature shell resembles closely that of Globigerina, but it differs in some important particulars. The pores are markedly

[1] 'Preliminary Notes on the Nature of the Sea-bottom procured by the Soundings of H.M.S. Challenger during her Cruise in the Southern Sea in the early part of the year 1874.' By Prof. C. Wyville Thomson, F.R.S., Director of the Civilian Scientific Staff on board. Read before the Royal Society, Nov. 26, 1874.

of two different sizes, the larger about four times the area of the smaller. The larger pores are the less numerous; they are scattered over the surface of the shell without any appearance of regularity; the smaller pores occupy the spaces between the larger. The crests between the pores are much less regular in Orbulina than they are in Globigerina; and the spines, which are of great length and extreme tenuity, seem rather to arise abruptly from the top of scattered papillæ than to mark the intersections of the crest. This origin of the spines from the papillæ can be well seen with a moderate power on the periphery of the sphere. The spines are hollow and flexible; they naturally radiate regularly from the direction of the centre of the sphere; but in specimens which have been placed under the microscope with the greatest care they are usually entangled together in twisted bundles. They are so fragile that the weight of the shell itself, rolling about with the motion of the ship, is usually sufficient to break off the whole of the spines and leave the papillæ only projecting from its surface in the course of a few minutes. In some examples, either those in process of development, or a series showing a varietal divergence from the ordinary type, the shell is very thin and almost perfectly smooth, with neither papillæ nor spines, nor any visible structure, except the two classes of pores, which are constant.

The chamber of Orbulina is often almost empty; even in the case of examples from the surface, which appears from the freshness and transparency of the shell to be living, it is never full of sarcode; but it frequently contains a small quantity of yellow sarcode stuck against one side, as in the last chamber of Globigerina. Sometimes, but by no means constantly, within the chamber of Orbulina there is a little chain of three or four small chambers singularly resembling in form, in proportion, and in sculpture, a small Globigerina; and sometimes, but again by no means constantly, spines are developed on the surface of the calcareous walls of these inner chambers, like those on the test of Globigerina. The spines radiate from the position of the centre of the chambers and abut against the insides of the wall of the Orbulina. In a few cases the inner chambers have been observed apparently arising within or among the sarcode adhering to the wall of the Orbulina.

Major Owen regards Orbulina as a distinct organism, nearly allied to Globigerina, but differing so far from it as to justify its separation into a special subgenus. He considers the small inner chamber of Orbulina as representing the smaller chamber of Globigerina, and the outer wall as the equivalent of the large outer chamber of Globigerina developed in this form as an investing chamber. Count Pourtales, Max-Schultze, and Krohn, on the other hand, believe, on account of the close resemblance in structure between the two shells, their constant association, and the undoubted fact that an object closely resembling a young Globigerina is often found within Orbulina, that the latter is simply a special reproductive chamber budded from the former, and capable of existing independently. I am rather inclined to the latter view, although I think much careful observation is still required to substantiate it; and some even of our own observations would seem to tell somewhat in the opposite direction. Although Orbulina and Globigerina are very usually associated, in different localities, they are so in different proportions; and in the icy sea to the south of Kerguelen, although Globigerina was constantly taken in the surface-net, not a single Orbulina was detected. Like Globigerina, Orbulina is most fully developed and most abundant in the warmer seas.—Wyville Thomson, *loc. cit.*

Coccoliths and Rhabdoliths.—Over a very large part of the "Globigerina ooze" area, and especially in those intertropical regions in which the formation is most characteristically developed, although the great bulk of the ooze is made up of entire shells and fragments of shells of the above-described foraminifera, besides these there is frequently a considerable proportion (amounting in some cases to about twenty per cent.) of fine granular matter, which fills the shells and the interstices between them, and forms a kind of matrix or cement. This granular substance is, like the shells, calcareous, disappearing in weak acid to a small insoluble residue: with a low microscopic power it appears amorphous, and it is likely to be regarded at first sight as a paste made up of the ultimate calcareous particles of the disintegrated shells, but under a higher power it is found to consist almost entirely of "coccoliths" and "rhabdoliths." I need scarcely enter here into a detailed description of these singular bodies, which have already been carefully studied by Huxley, Sorby, Gümbel, Carter, Oscar Schmidt, Wallich, and others. I need only state that I believe our observations have placed it beyond a doubt that the "coccoliths" are the separated elements of a peculiar calcareous armature which covers certain spherical bodies (the "coccospheres" of Dr. Wallich). The rhabdoliths are the like elements of the armature of extremely beautiful little bodies, which have been first observed by Mr. Murray, and naturally called by him "rhabdospheres. Coccospheres and rhabdospheres live abundantly on the surface, especially in warmer seas. If a bucket of water be allowed to stand over night with a few pieces of thread in it, on examining the threads carefully many examples may usually be found attached to them; but Mr. Murray has found an unfailing supply of all forms in the stomachs of Salpæ.

What these coccospheres and rhabdospheres are we are not yet in a position to say with certainty; but our strong impression is that they are either algæ of a peculiar form, or the reproductive gemmules, or the sporangia of some minute organism, probably an alga, in which latter case the coccoliths and rhabdoliths might be regarded as representing in position and function the "amphidisci" on the surface of the gemmules of Spongilla, or the spiny facets on the zygospores of many of the Desmidæ. There are many forms of coccoliths and rhabdoliths, and many of these are so distinct that they evidently indicate different species. Mr. Murray believes, however, that only one form is met with on one sphere; and that in order to produce the numerous forms figured by Haeckel and Oscar Schmidt, all of which, and many additional varieties, he has observed, the spheres must vary in age and development, or in kind. Their constant presence in the surface-net, in surface-water drawn in a bucket, and in the stomachs of surface animals, sufficiently prove that, like the ooze-forming foraminiferes, the coccoliths and rhabdoliths, which enter so largely into the composition of the recent deep-sea calcareous formations, live on the surface and at intermediate depths, and sink to the bottom after death. Coccospheres and rhabdospheres have a very wide but not an unlimited distribution. From the Cape of Good Hope they rapidly decreased in number on the surface, and at the bottom, we progressed southwards. The proportion of their remains in the Globigerina ooze near the Crozets and Prince Edward Island was comparatively small; and to this circumstance the extreme clearness and the unusual appearance of being composed of Globigerinæ alone was probably mainly due. We found the same kind of ooze nearly free from coccoliths and rhabdoliths in what may be considered about a corresponding latitude in the north, to the west of Faröe.—Wyville Thomson, *loc. cit.*

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

HISTOLOGY.[1]

VII. Nervous System.—1. *On the Nerves of the Capsule of the Knee-Joint in the Rabbit.*—Nicoladoni ('Stricker's Jahrbücher,' 1873, No. 4) chose this object because the articular capsule is very thin and easily isolated. Excised portions were treated by gold chloride and dilute acetic acid and examined in glycerine. The nerve-fibres are thus shown as brownish or blackish lines on a rose-coloured ground. In good preparations it can be seen that numerous medullated fibres run in the subserous connective tissue, being only separated from the endothelium by a few capillaries. They divide into two or three thinner medullated branches, which soon terminate in a conical swelling, at which point the medullary sheath ceases, numerous pale fibres being given off, which ultimately communicate to form a network surrounding the endothelial and connective-tissue cells. The greater part of the nerves terminate in this manner, but once a non-medullated fibre was seen, which, after forming a delicate network, gave off a branch to small artery, finally terminating apparently in close connection with the nuclei of the muscular coat. A termination in Pacinian bodies also occurs, as Rauber had shown. They are always near the larger nerves, from which simple medullated fibres are given off, which soon enter an elongated oval body with concentric layers, where they terminate in a button-like swelling.

[1] The articles in this division are arranged under the following heads :—I. Text-books and Technical Methods. II. The Cell in General. III. Blood. IV. Epithelium. V. The Connective Tissues. VI. Muscle. VII. Nervous System. VIII. Organs of Sense. IX. Vascular System. X. Digestive and Respiratory Organs and Glands. XI. Skin and Hair. XII. Urinary and Sexual Apparatus.

The Editors will be glad to receive, for the purpose of making this record more complete, copies of separate memoirs or reprints from periodicals, which must otherwise often escape notice. We have to acknowledge the assistance of Dr. Cavafy in making these abstracts.

The wall itself is delicate, with only a few concentric connective-tissue layers with many cells in young animals.

2. *On Articular Nerves.*—Krause ('Histologische Notizen Centralblatt,' 1874, No. 14) states that the nerves of the finger-joints in man terminate in peculiar bodies which he calls articular-nerve capsules. Four nerve-fibres penetrate each corpuscle, which is rounded or oval, and consists of connective tissue longitudinally striated, with oval nuclei. In the interior of the capsule are numerous rounded or elongated nuclei, and a finely granular material, in which the terminal non-medullated fibres ramify freely. These have no analogy with Pacinian bodies according to Krause. Rauber, however ('Centralblatt,' 1874, No. 20), after stating that similar bodies are found on the nerves of the dorsum of the wrist-joint in great numbers, considers that they are modified Pacinian bodies.

3. *Changes in the Ganglion-cells of the Sympathetic in Inflammation.*—Robinson ('Stricker's Jahrbücher,' 1873, No. 4) studied these by passing a thread through the aorta in a frog, and, after two to seven days, killing the animal. The aorta was then cut out, treated with gold chloride, and examined in glycerine. He found that the peculiar, strongly granular aspect of the nerve-cells disappeared, furrows were formed on the surface, and finally the cell-body divided into small portions.

This division may either implicate the whole cell or only a portion of it, the remainder preserving its normal appearance. A similar change takes place in the cell-processes, but not so commonly as in the cell itself. The newly formed cells soon escape from the capsule when it is young and delicate; in older and tough capsules they remain longer, but also finally escape, and become distributed in the inflamed tissue.

4. *Nerves of the Digestive Canal.*—Prof. Arnstein (of Kasan) contributes a memoir on this subject to Pflüger's 'Archiv,' vol. viii (Abstract in 'London Medical Record,' 1874, p. 261).

5. *Terminations of the Nerves in the Cornea.*—Dr. Durante, in describing the results of researches on the nerves of the cornea made by him in the anatomical laboratory in Rome ('Rivista di Medicina, di Chirurg. e di Terap.,' and 'Gazz. Clinica di Palermo,' August and September), states that, by soaking the cornea of batrachians, rabbits, and dogs, in solution of chloride of gold, and keeping them at a temperature of 88° Fahr., he was, at the end of four days, enabled

to see a very distinct network of nerves.—*Abstract in 'London Medical Record,'* 1874, p. 35.

IX. Vascular System.—1. *Ventricular Septum of the Frog and the Rabbit*—F. Champneys ('Stricker's Jahrbücher,' also 'Journal of Anatomy and Physiology,' May, 1874) describes the general structure, muscles, nerve-fibres, nerve-cells, and endothelium of this structure.

2. *Histology of the Heart and its Coverings.*—Skworzow ('Pflüger's Archiv,' vol. viii, abstract in 'London Medical Record,' 1874, p. 262) discusses the lymphatics, nerves, and endothelium of the heart and pericardium.

3. *Structure of Vessels as shown by Nitrate of Silver.*—M. Reich ('Wiener Sitzungsber,' iii Abth., Bd. lxvii, 1873, p. 81; 'Centralblatt,' 1874, p. 589).

X. Digestive and Respiratory Organs and Glands.—1. *On the Mucous Membrane of the Larynx.*—Coyne ('Thèse pour le Doctorat,' Paris, 1874) studied the mucosa of the larynx on the true and false vocal cords and in the ventricle. The mucous membrane, which is smooth throughout nearly its whole extent, has numerous prominences in the ventricle, especially its external wall, which are simply folds of the membrane, and not due to papillæ, as erroneously stated by Luschka. Coyne confirms the existence of a basement membrane, which may, he suggests, consist of a layer of endothelium. The corium consists of two layers. The superficial layer is reticular in structure, and contains lymphatic follicles with a delicate reticulum in the ventricle, especially in the above-described mucous folds immediately beneath the basement membrane. These had not been previously described in man, but similar follicles have been found by Verson in the pig and sheep at the root of the epiglottis. At the free border of the true vocal cord the adenoid tissue is replaced by a dense fibro-elastic membrane covered with small simple papillæ. The deeper layer of the corium contains the mucous glands, which are large over the centre of the false vocal cord. The epithelium is squamous and stratified over the papillæ of the true vocal cord. On the free edge of the false vocal cord it is formed of three or four very regular layers of polygonal epithelium, over which there are two or three layers of flattened non-nucleated cells. In the remainder of the mucous membrane the epithelium is columnar and ciliated.

2. *On the Histology of the Villi of the Small Intestine.*—Thauhoffer ('Pflüger's Archiv,' 1873, p. 391) describes the hyaline striated band at the base of the epithelium as being an appearance due to the apposition of a number of minute,

rod-like processes, which are directly connected with the protoplasm of the cell, the hyaline layer rarely encircling the base, but leaving the surface naked. They have been seen in movement in frogs after injury to the spinal cord or medulla oblongata, but not in warm-blooded animals. The movements are stated to be active during the absorption of fat, whose particles are seized by the processes, which are then retracted, so that after the cell is gorged with fat the striated band is no longer visible, the cells being bounded only by a homogeneous layer. The author confirms Heidenhain in stating that the extremities of the epithelial cells are provided with one or two processes which communicate with connective-tissue corpuscles in the stroma of the villus. In addition, there is a delicate process coming off from the nucleus of the epithelial cell, and passing to granular cells with a vesicular nucleus, three or four times larger than the connective-tissue corpuscles. These the author considers to be nerve-cells. Hence the epithelium has processes of two kinds—connective-tissue processes, rarely more than two in number, and a nervous process which is always single.

The connective-tissue corpuscles form a network communicating with the central lacteal, but not with the capillary blood-vessels, and thus furnish a channel of absorption for the chyle.

3. *Blood-vessels of the Small Intestines.*—A. Heller (Ludwig's 'Arbeiten,' vol. vii) arrives at the following results:—1. Every villus contains an artery which runs, as a general rule, to the point of the villus without branching. In man only does it begin from the middle of the villus to lose itself in a capillary network. 2. The vein begins either in the point of the villus (rabbit, man) or near to the same (rat), and generally goes directly into the submucous tissues without receiving any lateral branches; or it rises near the base of the villus, and receives more or less numerous lateral branches from the glandular layer (dog, cat, pig, hedgehog). 3. In none of the animals examined was there to be found the often-cited arrangement of an arterial stem going to the point of the villus, and of a descending venous stem with a simple connecting capillary network between both stems. This is of importance with regard to the erection of the villus ('London Medical Record').

4. *Dentine, Enamel and Cement*, by J. Kollman ('Zeitschrift f. Wiss. Zoologie,' xxiii, p. 354).

XI. Skin and Hair.—*The Structure of the Skin.*—Professor Tomsa, of Kiew, in Russia, publishes ('Archiv f. Dermatologie und Syphilis,' 1873, vol. i; abstract in 'London

Medical Record,' 1874, p. 131) a long and elaborate paper on various points on the anatomy and physiology of the skin.

XII. Urinary and Sexual Organs.—1. *On the Structure and Movements of Spermatozoa.*—By Th. Eimer ('Verhandl. der Phys. Med. Gesellschaft in Würzburg,' vol. vi, p. 93).

2. *On the Structure and Development of the Ovary and Wolffian Duct.*—By G. Romiti ('Arch. f. Micr. Anatomie,' 1874, No. 2).

3. *Anatomy and Histology of the Testicle.*—V. von Mihalkovics ('Bericht der Math.-phys. Classe der Königlichen Sachs. Gesellschaft der Wissensch.,' 1873), under the direction of Ludwig and Schwalbe, has investigated the course, structure, and contents of the seminal tubes, the interstitial tissue of the testicle, and the lymph-vessels and the blood-vessels of the testicle and epididymis. Besides those of the human subject, the testicles of the rabbit, guinea-pig, rat, mouse, dog, cat, hedgehog, boar, goat, bull, and several birds (pigeons, &c.), were examined. The paper is beautifully illustrated with several coloured plates. The author has arrived at the following conclusions:

(1.) The convoluted tubules form a network by dividing dichotomously. The terminal branches arising from this division are connected together by loops. No bud-like dilatations of the wall of the seminal tubes are to be found in the cortical layer of the human testicle. The author thus disposes of the view that the convoluted seminal tubes arise by blind extremities, as supposed by Beale, Henle, Kölliker, and Sappey.

(2.) The tubuli recti are not simple prolongations of the contorted tubules, but excretory tubes, which lie in the tissue of the organ of Highmore and in the lower end of the septa.

(3.) Supporting cells (Stützzellen) and germinal nets (Keimnetz) are artificial products. They owe their origin to the coagulation of a tough substance, rich in albumen, which lies between the seminal cells. On the addition of hardening reagents, coagulation occurs, and a network appears between the seminal cells.

(4.) The interstitial cells are constituents of the testicle, whose analogues are also to be found in other organs (coccygeal and carotid glands and corpus luteum).

(5.) The connective tissue of the testicle consists of finer and stronger bundles of connective tissue, which form networks and are enveloped by endothelial cells. The mesh-spaces are in many places bridged over by their endothelial membrane, which then passes over to and becomes continuous with the outermost layer of the seminal tubes, and also envelopes the blood-vessels.

(6.) The lymph-passages arise partly in the mesh-spaces of the connective tissue enveloped in endothelium, and partly in the spaces of the individual lamellæ of the walls of the seminal tubules. Proper lymph-vessels enclosed within tube-like walls do not occur in the parenchyma of the testicle.

(7.) A capillary network of blood-vessels, lying in intimate connection with the membrana propria, is closely woven round the seminal tubules.

(8.) The epididymis is not only an excretory tube, but also the place for the secretion of the fluid constituents of the seminal fluid (Dr. Stirling, in 'London Medical Record,' 1874, p. 321).

4. *Retrogressive Changes of the Epithelial Cells in the Serous Layer of the Ovum of the Rabbit.*—K. Slavjansky (Ludwig's 'Arbeiten,' vol. vii) describes the degeneration, called by him reticular ("reticulare degeneration"), which the epithelial cells of the serous layer of the ovum undergo in their physiological development. During the development of the ovum, the epithelial cells of the part of the serous layer lying close to the umbilical sac become thin and flat, and in the cells themselves some transparent spots are to be observed. By-and-by the protoplasm disappears, and holes are observed in the cells. These holes gradually enlarge, so that, at last, in place of the epithelial membrane, there is to be seen a reticulum of the remains of the protoplasm of the epithelial cells, containing in some places the nuclei. There is thus established a physiological prototype for the pathological degeneration of the epithelium, described by Wagner under the name of fibrinous degeneration, in cases of croup and diphtheria ('London Medical Record,' p. 226).

5. *Development of Seminiferous Tubes.*—Sernoff publishes an abstract of a Russian memoir on this subject ('Centralblatt,' 1874, p. 481).

EMBRYOLOGY.

Rhizopoda.—We have not space to do justice in the present number to the remarkable papers which have been published during 1874 touching the fresh-water Radiolarians, tending, as these papers do, to establish and to extend the important series of facts which, it should be clearly understood, had been already published in this Journal by Mr. Archer, of Dublin, before the paper of Focke, and long before Greef's first papers on the subject.

Franz Eilhard Schultze, in 'Arch. für Mikrosk. Anat.,' vol x, third part, describes "*The structure and reproduction of Actinosphærium Eichornii*," multicellular structure of adult, encystation in a jelly, breaking up into ten "sporules," each of which becomes enclosed in a *siliceous* hexagonal shell. The same author, in a paper in the fourth (last published) part of vol. x of the same 'Archiv,' describes and figures a new species of Archer's genus Raphidiophrys, also three new genera, one a stalked form, like *Clathrulina*, but devoid of siliceous capsule.

A supplementary number of the same 'Archiv' (1874), of 220 pages and five plates, gives an account of studies carried out on Heliozoa and Amœboidea by *Dr. Richard Hertwig* and *E. Lesser*. The forms described come from the neighbourhood of Bonn. In a first chapter the authors show that Mr. Archer's *Gromia socialis* and his *Cystophrys Haeckeliana* are one and the same thing, viz. a colony-forming amœboid rhizopod, which they term *Microgromia socialis*. A variety of new genera and species are subsequently described and figured, and classification of the groups given, with frequent reference to and discussion of Mr. Archer's observations.

Spongiæ.—*Metschnikoff*, in *Köll.u. Siebold's Zeitschrift*, first part, 1874, takes up the development of certain Calcareous Sponges, and makes his observations the ground for a severe attack upon Haeckel. He studied *Sycon ciliatum*. It is not impossible that the difference of his results with those given by Haeckel is due to the difference of species studied. This he does not take into consideration. The eggs undergo cleavage whilst still attached to the endoderm of the parent sponge-cup. Later the embryos escape, and may be obtained in the glass vessel in which the specimens are kept, by placing glass slips conveniently for their adhesion. The observations were made in the spring of 1868, at Messina. The ciliated swimming embryos are composed of cells surrounding a cleavage cavity. The anterior cells only are ciliated (as described in other sponges by earlier authors). The cleavage cavity disappears, the *ciliated cells* become invaginated, losing their cilia, and form the endoderm, whilst the large unciliated cells form the skeleton-building layer of the young sponge. The orifice of invagination closes, and probably a secondary orifice breaks through at a later period, to form the permanent mouth or excurrent aperture of the sponge-polyp. In the cases studied by Haeckel an invagination is not described, but the diploblastic planula, without any orifice, is described as forming its endoderm by *delamination*, an orifice (regarded as the mouth) subsequently breaking through and completing the "gastrula," which then becomes fixed by attachment of the aboral pole. Metschnikoff did not find the endoderm to be ciliated in the species studied by him, after fixation, whereas Haeckel did in the cases studied by him.

Carter, in the *Annals and Mag. Nat. Hist.*, Nov. and Dec., 1874, gives an account of observations on the development of Siliceous Sponges, which will be found of interest in connection with the above.

Hydrozoa. — *Metschnikoff* describes the development of many *Medusæ* and *Siphonophora* in a paper in *Koll. u. Sieb. Zeitschrift*, part i, 1874, illustrated with eleven folding plates. He again finds occasion to differ very largely from Haeckel, whose prize memoir on the development of the Siphonophora is the most complete account at present published of this matter. The most interesting part of Metschnikoff's memoir is that in which he discusses some parts of the Gastrea-theory, and in particular expounds his views as to the nature of the cœlom or body-cavity and the relationship of the Echinodermata and Cœlenterata. He dissents altogether from Haeckel's view, adopted by Gegenbaur, that the Echinoderms are to be regarded as radial colonies of worm-like individuals arranged around a common stomach. Metschnikoff draws attention to the confirmation which he has previously given to Alex. Agassiz's observation, to the effect that the ambulacral system is an outgrowth of the alimentary canal of the larva, and further, that *the whole peritoneal system* of the Echinoderm is of the same nature and quite distinct from the body-cavity of the larva. In this case Metschnikoff contends that the cavities of the Echinoderm's body, outside the alimentary canal, are directly comparable to the gastrovascular system of Rhizostoma and the Ctenophora. In Bipinnaria the cavities in question communicate provisionally with the gastric cavity which in the larva takes its rise by invagination—a condition which in the Cœlenterata exists throughout life. The two openings of the canal system of Ctenophora Metschnikoff regards as corresponding to the pore of the ambulacral system, which is double in some Echinoderm larvæ. Further, he will not allow that in Cœlenterata there is no representative of a true body cavity, that is, of a cavity arising between the body-wall and intestinal wall, independent of all communication with the alimentary cavity. This he finds in the space occupied by the jelly-mass in Medusæ and Ctenophora, in which so-called "mucus-tissue" is often developed. This corresponds with the true body-cavity of the Echinoderm-larva, which is filled up with a jelly-like substance, and in which stellate connective tissue-cells often develop. At the same time Metschnikoff holds the Echinoderms and the Cœlenterates to be two distinct types, which must, however, be placed near one another in classification. He finds the same degree of similarity between them as between the higher worms (Hirudines, Gephyræa, and Annelids) and the Arthropods.

Edouard Van Beneden, under the title "De la distinction originelle du Testicule et de l'Ovaire" (Brussels, 1874), has published an exceedingly important account of the development of the sexual products in *Hydractinia echinata*, accompanied by some general considerations of philosophic import. After reviewing recent writings, in which the inference has been drawn that throughout the animal kingdom ectoderm and endoderm are homologous (homogenous) structures, Van Beneden proceeds to point out the discrepancy in the various accounts of the origin of the sexual products in the Cœlenterata, those organisms which, as he justly observes, most readily lend themselves to the investigation of the question, from which of these two layers are the ova and the spermatozoa respectively developed. One source of discrepancy is no doubt this—that few observers have made use of the system of cutting sections, or, on the other hand, have employed species for observation which are sufficiently transparent to allow of a perfectly satisfactory examination of the problem. Furthermore, there is this undoubted fact, which is well recognised in the case of the generative and other organs throughout the animal series, namely, that an organ travels very frequently in the course of its development to a considerable distance from its seat of origin, and comes to occupy a totally different relation to surrounding parts from that which it primitively occupied. Hence, unless an observer detects the actual very first commencement of ovary or testicle, he may be led to assign to them as a seat of origin some intermediate position occupied by them secondarily, or *in transitu*. Van Beneden finds in *Hydractinia* that there is a very interesting mode of development for the testicle, similar, we may record, to what Kleinenberg, of the Zoological Station, Naples, has recently observed by careful sections in the case of *Tubularia indivisa*. The testicle and spermatozoa develop at the expense of the ectoderm, and result from the progressive transformation of a cellular fold formed primitively *by invagination*. The eggs, on the other hand, are developed exclusively at the expense of the epithelial cells of the endoderm. They remain, up to their maturity, surrounded by the elements of the endoderm. Moreover (and this is of the highest interest and significance, and may serve to explain contradictory statements in other authors' results), in the female sporosacs of *Hydractinia* there is an invagination of a rudimentary character which represents the male organ; in the male sporosacs, on the other hand, rudimentary ovules develope in the endoderm. The sporosacs are, therefore, primitively hermaphrodite.

Professor Van Beneden gives very beautiful figures of the development of the parts in question, and his facts admit of no doubt. The discovery of the ectodermal origin of the testis and of the endodermal origin of the ovary, is one of *first-rate* importance. The necessary additional basis of observed fact, in other Cœlenterata, in Vermes, &c., will, no doubt, soon be forthcoming, and we shall then be in a position to judge definitely of the value of the very important generalisation to which Professor Van Beneden, with much reason, commits himself, namely, that throughout the animal kingdom the testis is ectodermal, the ovary endodermal; that therefore the outer layer or epiblast of the embryo may be called neuro-muscular and male, whilst the inner layer or hypoblast is alimentary, vegetative, and female. It is remarkable that recorded observations coincide with this. Huxley traced the male reproductive elements in medusæ to the ectoderm, whilst Haeckel no less definitely assigned the ova to the endoderm. Allman, in writing in this Journal of the origin of the sexual products in Hydrozoa generally, observed that they appeared in a cellular mass between ectoderm and endoderm, which at the present could not be assigned with more reason to the one than to the other. But the most important confirmation of Professor Van Beneden's view is furnished by the Vertebrata. Here, as nowhere else, the origin of the sexual glands has been investigated from the earliest stages by many observers, and by the most refined methods of section-cutting, &c. Van Beneden remarks that "it results from all the more recent embryological investigations of vertebrata that the middle layer of Von Baer and of Remak gives rise only to the epithelium of the primitive peritoneal cavity. Now, according to the observations of Waldeyer, the superficial epithelium of the ovary of Vertebrates is only that part of the peritoneal epithelium which covers the middle plate (mittelplatte of Remak, intermediate cell-mass of Balfour and Foster). The observations of Götte, of Peremeschko, of Schenk, of Oellacher, of Rieneck, have demonstrated that the internal layer and the middle layer of Remak are but differentiated parts of one and the same cellular layer (the endoderm), which arises entirely from the white yelk in the case of the Batrachians. The female sexual epithelium, which persists at the surface of the ovary of mammals, at the expense of which the ovarian tubes are formed, the vesicles of Von Graaf and the canals of Müller, are derived then in ultimate analysis from the endoderm. The testicle is formed at the expense of the Wolffian canals, according to the observations of Waldeyer and several other embryologists. Now, His, Hensen, and Waldeyer derive the Wolffian duct from the outer layer (ectoderm) by the intermediation of the axial cord. Accordingly, the testicle would also be derived in the Vertebrata from the ectodermic layer. My conclusions are thus confirmed, even at the present moment, as far as concerns the group of the Vertebrata."

Nemertine Worms.—The very handsome work of *Dr. McIntosh* published by the Ray Society has arrived at a second part, in which histological details and some embryological facts are given with that excellence of illustration which renders the work so conspicuous among English contributions to modern zoology.

Dr. A. A. W. Hubrecht, at present assistant to Professor Selenka, of Erlangen, prosecuted some interesting researches upon Nemertines at the Zoological Station, at Naples, during the spring of 1874. These furnish the subject for a *Graduation thesis* just published in Dutch, at *Utrecht.* New species and genera of considerable interest are described, as also the minute structure of the nerve-ganglia. Hæmoglobin was detected by means of the spectroscope in the nerve tissue of two species of *Meckelia,* and in true red blood-corpuscles in *Drepanophorus.* An important developmental fact is established by Hubrecht's observation (and figure) of the formation of an *invaginate Gastrula* (precisely similar to that of many Molluscs), in the early stages of *Borlasia olivacea.*

Nematoid Worms.—In Lacaze Duthier's 'Archives,' 1st and 2nd parts for 1874, is a monograph, by *M. Villot,* on the 'Dragonneaux,' or genus *Gordius.* The development of *Gordius aquaticus* within the egg and in subsequent phases of encystment is illustrated in the plates. This monograph will serve as a valuable guide to those who wish to pursue further the structure and development of these remarkable worms, since M. Villot has made a very careful study of their habits and migrations, as well as of their specific characters. M. Villot finds that the young *Gordius aquaticus* first makes its way into insect larvæ (such as *Chironomus*), and becomes encysted, after which it finds its way with its host into the alimentary canal of fishes, where it is again encysted. It escapes from this position per anum in the spring. M. Villot's memoir shows throughout a due recognition of the labours of earlier observers, such as Grenacher, Meissner, Siebold, and others.

Arthropoda.—In the second part of *Köll. und Sieb. Zeitschrift*, 1874, *Bobretzky* has a paper on the embryology of *Oniscus murarius*, which is important from the apparent success which the author has obtained in cutting sections of such small and friable eggs as those of this Isopod. An earlier paper by the same author, in the Russian language, is referred to, in which a similar treatment of the eggs of *Astacus fluviatilis* and *Palæmon serratus* had led to similar results. We venture once for all to appeal to Russian embryologists, who are at present so greatly distinguishing themselves in this line of research, to abstain from publishing the accounts of important new observations in a language which is inaccessible to western Europeans. We submit that, on account of the literary importance of those languages in other directions, it is desirable, for scientific purposes, to employ either English, French, or German as the language of science; and simply on account of the number of cultivated persons throughout the civilised world who are familiar with one or other of these three languages, we should advocate the adoption of English or French in preference to German, by scientific writers whose native tongue is not included under the three languages specified.

Bobretzky finds in Oniscus the representatives of the three chief embryonic cell-layers present in the Vertebrata. The so-called food-yelk becomes organized, or, to a large extent, converted into cellular elements, and is regarded by him as hypoblast. Previously to this, by segregation of a patch of plastic yelk and its cleavage, an epiblast has been formed which covers, by gradual extension, the entire surface of the egg. Mesoblastic cell elements take their rise between this and the large mass of granular yelk. It is not clear from Bobretzky's observations whether the hypoblast-cells which appear throughout the granular yelk-mass arise *there* by a deep segregation, or whether they penetrate to that position by extension from the "germinal heap" which forms below the epiblast at one pole of the egg. The subsequent differentiation of these cells is in accordance with the most usual (but, as we believe, *not invariable*) disposition of such elements. The epidermis and great nerve-ganglia are formed from the epiblast cells, as also the fore part and hind part of the alimentary canal. The hypoblastic cells arrange themselves so as to form a straight fore and aft middle intestine, joining the fore and hind in-pushings of the epiblast, to wit, pharynx and rectum. From the sides of this central mass, at an early period, the hypoblastic cells arrange themselves so as to embrace the great mass of unorganized yelk in two diverticula of the middle intestine—the two liver sacs. This enclosure of the food-yelk by the hypoblast is remarkable in the animal series as *not* being constant, for it frequently happens, even in genera closely allied to those in which such an enclosure takes place, that the reverse of this disposition is carried out, so that diverticula of the middle intestine push their way *into* the mass of food-yelk, which lies then between them and the mesoblast, and apparently absorb it from the outside instead of from the inside after enclosure. The mesoblast in Oniscus, as in all other animal types possessing a body cavity (due allowance being made for the disputed case of Echinodermata), disposes itself so as to line the two limiting surfaces of that cavity—the tegumentary and the alimentary—furnishing muscles and skeleton. It also gives rise to vascular and circulatory organs by outgrowths into the body cavity.

The Embryology of the Myriapoda is attacked by the indefatigable *Metschnikoff* in *Kölliker und Sieb. Zeitschrift*, part iii, 1874, under the title "Embryology of the double-footed Myriapoda (Chilognatha)." The observations refer to species of Strongylosoma, Polyxenus, Polydesmus, and Julus. They are the first studies of Myriapods' development, carried on from the histogenetic point of view. Newport's researches, which dealt only with external form, were the only observations up to this time.

Metschnikoff says that he expected to find the amnion of Newport's *Julus* the same as the insect-amnion, and a general agreement between Myriapods and Insects in their development. Instead of this he finds very great differences, as great as any between two groups of Arthropods. Firstly, in Myriapods there is a total cleavage of the yelk. This occurs in representatives of all Crustacean orders, more rarely in the Arachnida, but *never* in Insects. Thus the Myriapods agree with the Crustacea, but "it is to be observed," says Metschnikoff, "that there is no fundamental difference between the formation of the blastoderm in these groups." Whether the plastic yelk is segmented or not, the cellular elements of the blastoderm are thrown off by it so as to form the superficial cell-layer. In many Insects the food-yelk cleaves after the separation of the blastoderm. Secondly, in the Myriapoda there are two germ-layers to be distinguished: an outer, agreeing in its differentiation with that of Scorpio, Araneids, Insects, and many Crustacea, since it forms the central nerve-system, the epidermis, and the epithelial lining of the pharynx and rectum and the tracheal tubes; a deeper layer which divides itself into a number of protovertebræ-like segments, the embryological significance of which is not apparent. They give rise to the muscles, the body cavity (by splitting), and perhaps the mid-intestine. Kowalewsky first saw these in the Earth-worm, Metschnikoff in Scorpion, and later in Spiders, in Mysis, and other Crustacea. They do not appear to have been recognised in any of the many Insects studied recently by embryologists, except in the Termites. Thirdly, the embryonal membranes of Arthropods are of great importance; they are of two kinds, cellular and structureless. Metschnikoff thinks that they cannot be held in any way to represent one another. Insects have an amnion built up of cells, the best figures of which are to be seen in Kowalewsky's paper, *Mem. Acad. St. Petersburg*, seventh series, vol. xvi, No. 12, 1871. Crustacea have structureless "larval skins," which are shed in the egg. Metschnikoff has found such larval skins also in Insects; for instance, in Platygaster and other Pteromalina. Claparède found them in Acari. In Myriapods we can only compare Newport's amnion and a second structureless membrane also present with the larval skins of Crustacean embryos. In particular, the cuticular vesicle, which was found by Fritz Müller in the Isopod *Ligia* and is held by some embryologists to be a nauplius-skin, presents close agreement with the inner retort-shaped membrane of a Julus-embryo. Hence, again, the Myriapods separate themselves from the Insects.

Fourthly, this assimilation in development to the Crustacea rather than to the Insects is more strongly confirmed than by any other fact, by the peculiar curvature of the embryo. Instead of the primitive neural region (*keim-streif*) being convex outwardly and concave to the yelk—bending up round it at each end when seen in vertical antero-posterior-section, as in all Arthropods except the higher Crustacea (especially Amphipoda)—instead of this, all the Myriapods studied show the Amphipod's position, having the neural surface concave by the bending over of the tail and head on this side towards one another. This appears to be a fact of high significance.

Fifthly, it is remarkable that here, as a further disagreement with what occurs in Insects, and agreeing with what occurs in some Crustacea, *e. g.* Daphnoidea, we find that in the Myriapods the food-yelk is not enclosed *within* the parietes of the alimentary canal or its diverticula, but lies outside it in the body cavity between the alimentary and tegumentary walls. (See abstract of Bobretzky on *Oniscus*, above.)

These researches tend to connect the stem of the Insects with the Hedriophthalmatous Crustacea through the Myriapods. It appears that Packard's recent observations on "Development of Poduridæ" ('Peabody Academy,' vol. i) show that in these archaic insects there are no cell-structured embryonic membranes, but instead a chitinous skin, "like the larval skin of many Crustacea." Ulianin, of Moscow, has further found that Poduridæ agree with Myriapoda in having a total yelk-cleavage.

Two points of grosser morphological (that is, relating to the plan of disposition of parts of a coarser or higher order than the ultimate cell-unit) significance may be cited here. Metschnikoff finds that the post-oral jaw-pieces are only two pairs in the Diplopods studied by him, viz. mandibles and the halves of the underlip, which fuse to form a plate, as do the second pair of maxillæ (third "post-orals") of Insects. No trace of a second pair of maxillæ was found by Metschnikoff in Myriapods, nor by Packard in Poduridæ. On the other hand, it is not true that the Diplopod has a definite hexapod larval state. The third, fourth, and fifth pairs of post-oral appendages are large, and develop early, but before the embryo escapes. Metschnikoff finds a sixth, seventh, eighth, and ninth pair of post-oral appendages, that is, seven pairs of legs in all, the hinder ones being, it is true, small (seven pairs in *Julus,* six pairs in *Strongylosoma*).

Mollusca.—*Salensky*, in the *Archiv fur Naturgeschicte,* 1874, has a paper on the Gastraea-theory, in which he offers some observations on the development of the common Oyster. He does not clearly apprehend the fact that there are two modes in which the diploblastic planula of Lankester (the gastrula of Haeckel, and, as Salensky now calls it, the diblastula) develops in the animal series, namely, by ***invagination*** of a primitive hollow polyplast or multicellular sac, and by ***delamination*** from the inner wall of such a sac. Further, he is mistaken in supposing that the orifice of invagination observed by Lankester in various Mollusca has anything to do with the mouth. Time will put this (which is a matter of fact) in its true light.

Usoff has published a preliminary notice of observations, carried out at Naples, on the development of the Dibranchiate Cephalopoda. His paper is devoid of illustrations. One of his chief objects appears to be to demonstrate the existence of cell-layers corresponding not only to the epiblast and hypoblast of Vertebrates, but of tegumentary, vascular, and alimentary layers of the mesoblast. In his statements as to the origin of the eye, ear, and pen-sac being invaginations of the epiblast, he has been anticipated by Lankester ('Proc. Roy. Soc.,' No. 151, 1874; 'Annals of Natural History,' February, 1873; and this Journal, October, 1874).

Grenacher (*Kölliker and Sieb. Zeitschrift*, No. 4, 1874) also describes the development of an unknown Dibranchiate Cephalopod, the eggs of which were found floating during his voyage to the Canary Islands. Very important results as to the development of the eye and "white-body" are given, which are in general accordance with those given by Lankester in another part of this number of the Journal.

On the First Developmental Phenomena in the Egg of the Pond-mussel, by *Professor Flemming*, of Prague ('Archiv fur Mikrosk. Anat.,' vol. x, 3rd part), is of great value, since it gives a very minute study and figures of the cleavage process in regard to the question of nucleus and germinal vesicle. The latter, Flemming shows, is extruded as Richtungsbläschen. He also shows that the nuclei become diffused before each act of self-division of a cleavage-segment, and that they re-form around centres indicated by radiating lines of fine granules, denoting the presence of movements towards a central spot.

Tunicata.—*Salpa pinnata.*—*Professor Todaro* has communicated some observations on the development of this animal to the *Reale Accademia dei Lincei*, Feb. 1st, 1874. He describes the segmentation of the egg, and the formation of a Baer's cavity, the cover of which has three layers as in Vertebrates. Then a Rusconian cavity forms, whether by invagination or with any trace of invagination, is not stated. The placenta now commences to take on a large development, whilst further, an amnion and amniotic cavity develop themselves. The maternal organism exhibits a true uterus, with outer smooth muscular coat, a middle vascular tunic, and an inner epithelial lining.

The Production of Buds in the Ascidians, by Prof. A. Kowalewsky ('Archiv fur Mikr. Anat.', vol. x, 4th part), with two plates.

Semper (*Verh. Phys. Med. Gesselsch. Wurzburg*, viii Bd.) gives an account, with two plates, of his study of the *development of the Cellulose tunic of the Ascidians.* The same subject had been recently treated by *Dr. Oscar Hertwig*, in the 'Jenaische Zeitschrift,' vol. vii, p. 46. Hertwig arrived at the following results: The outer cellulose-impregnated test of Ascidians is not secreted from the "testa-cells" of the egg (the persistent ovarian capsule of yellow cells, supposed by Kupffer to originate by free cell-formation from the yelk of the egg itself, by Kowelawsky to be cells of the egg-follicle), nor do the testa-cells become the cells of the test, but the test is a cuticular formation derived from the true epidermis which lies below it, and which can always be detected in the adult. Into this gelatinous cuticula cells from the epidermis wander (not in *Appendicularia* and *Doliolum*), and form there a structure having a resemblance to stellate connective tissue. It is these cells which give rise to the various cells characteristic of the test in different genera. Further, villi from the body wall covered with true epidermis, and more deeply lined by true connective tissue, and continuous with the hæmolymph cavity of the Ascidian, may also push their way into this remarkable tegumentary excretion, and there give rise to branching "blood-vessels," which have no inner (mesoblastic) epithelium. Hertwig has obtained the cellulose reaction from the deeper tissues of some Ascidians (Cynthia), such as muscular tissue and wall of the intestinal canal. Semper, only too clearly influenced by the same unfriendly disposition towards the Jena School as he evinces in a paper (noticed below) on the segmental organ of sharks, whilst he is obliged to confirm Hartwig's observations, sneers at him as a young observer, and proceeds to an elaborate attack upon his use of the term "Bindesubstanz," which has only the emptiest verbal importance. Semper sides with Metschnikoff and Kupffer against Kowalewsky, as to the origin of the testa-cells. He holds that they proceed from the yelk, and compares them to the Richtungsbläschen of Mollusca. (The Reporter must remark that it is certain in the cases of several Mollusca that the Richtungsbläschen are the escaped germinal vesicle. Further, he would draw attention to the accumulation of epidermic cells often seen on the surface of Fritillaria furcata, corresponding to the mantle-cuticle of other Tunicates with its in-wandered cells).

Vertebrata.—*General Treatises.*—'Embryology of Vertebrates,' by *Foster* and *Balfour*, is published by Macmillan. The present volume is the first of three, and deals with the development of the chick in great detail. Two succeeding volumes are contemplated to treat of the other Vertebrata in a comparative manner, and of the Invertebrata—an amount of space which the authors will find quite inadequate if they deal with the subject as fully and clearly as they have in the present volume. The points of critical interest in the present treatise have already appeared in the pages of this Journal (1873), as well as many of the drawings, which are transferred to its pages in the form of woodcuts. A great merit of the book is that it takes up the embryology of the Chick in such a way that the University student can with its aid, and the usual appliances of a laboratory, master for himself the whole question, as it at present stands, in a *practical* way—the only way in which he should ever be called upon to master it. The directions at the end of the book for the treatment of the incubated and unincubated egg—as to opening, hardening, staining, cutting, and mounting—are simple, clear, and to be relied upon absolutely.

The '*Lehrbuch der Vergleichenden Embryologie der Wirbelthiere*,' by *Professor Schenk*, published recently (1874) at Vienna, is a book of a very different kind. It contains a large amount of information, and very beautiful woodcuts—chiefly (though not exclusively) derived from original memoirs on the development of Batrachia, Osseous Fishes, and the Chick, by Stricker, Klein, Oellacher, Götte, and others. A certain number are original, and illustrate original observations, of the author. It does not in any way justify its title as a text-book of comparative embryology; it rather furnishes some of the materials for such a treatise, which has yet to be written, and, indeed, cannot be written until more is known of the development of Amphioxus, the Cyclostomata, the Elasmobranchs, and even of the Mammalia. Professor Schenk's volume, with its numerous illustrations, will be found valuable as a compilation from some of the most recent German writers on the embryology of the higher Vertebrata; as such we recommend it to the advanced student of embryology; but it must be understood that the material is not digested, nor of such a nature as to be useful to the commencing student. In this respect it contrasts strongly with the English text-book above noticed.

Schenk, on the Egg of Raja quadrimaculata, Bonap., whilst within the Oviduct.—('Wiener Acad. Sitzungsber.,' lxviii, 1 abth., 1873, with one plate).

A. Rauber, on the Embryonal Area of the Chick, in 'Centralblatt' (Oct. 24). The author remarks that the embryonal area of the Bird is in comparison with that of the Osseous Fish only equivalent to the foremost portion of the latter. In this relationship, however, the conditions are given for the setting free, in the case of the Bird, of large portions of the germ in the formation of an amnion.

The Formation of the Layers of the Blastoderm and of the Blood in the Hen's Egg, by *Alexander Götte,* is published in 'Max Schultze's Archiv,' vol. x, part 2. The deep cleavage of the yelk discovered by Götte, and announced in this paper, has been confirmed by Mr. Balfour, and a similar condition observed by him in the Dog-fish (see this Journal, October, 1874).

Skeleton and Muscles.—Schenk, in the text-book above noticed, states that in sections of early human embryos (long) he finds evidence of the existence of more than five fingers. Carl Vogt, in reference to the occasional occurrence of six-fingered men, has maintained that the early ancestors of man must have possessed more than five digits. This, however, must have been, we may remark, in ancestors of an earlier grade than the first Pentadactyla, a group which includes all the known Vertebrata, with the exception of the extinct Enaliosauria and the Fishes, Lampreys and Lancelet.

Frenkel (*Jenaische Zeitschrift* 1873, pp. 391-457) discusses the development of the Mammalian sacrum. Gegenbaur has shown that in Birds and Reptiles, of the numerous vertebræ taking part in the formation of the sacrum, only two are provided with sacral ribs and united to the iliac bones. These, then, are the *true* sacral vertebræ, the rest are pseudo-sacral vertebræ. Frenkel studied the sacrum of Man, Dog, Cat, Guinea-pig, Rabbit. He finds in Man, that the three anterior sacral vertebræ alone take part in the sacro-iliac synchondrosis, and possess true sacral ribs. They have each five centres of ossification; the two lower sacral vertebræ have only three each.

The Primitive Vertebrate Limb or Archipterygium.—Gegenbaur in the 'Jenaische Zeitschrift,' vol. vii, in consequence of the exceedingly important discoveries of Günther as to the structure of the fin-skeleton in the new Australian Dipneuston—*Ceratodus Forsteri*—modified to some extent his previous teaching as to the nature of the primitive vertebrate limb. The Archipterygium is, according to him, closely represented by the fin of Ceratodus with its axial segmented cartilaginous rod provided on each side (lateral or outer and medial or inner) with diverging radial pieces. In Protopterus the medial series of radials are suppressed, in Lepidosiren both medial and lateral series. In Sharks the lateral radials are enormously developed, the two proximal ones of the series being transferred from attachment to the Archipterygial basal piece to direct articulation with the shoulder-girdle, and constituting there the Mesopterygium and Propterygium, whilst the original basal piece is the Metapterygium. In the paper referred to on the Archipterygium Gegenbaur gives evidence of the existence in Sharks of medial radialia, developed it is true to but a small extent, but still present. In the 'Jenaische Zeitschrift,' vol. viii, part 2, 1874, A. Bunge, of Dorpat, gives additional evidence from various Selachian genera of the double series of radials with which the Archipterygium is typically furnished.

Urogenital organs.—Coincidently with the important researches of Mr. Balfour on the Elasmobranchs, published in this Journal, October, 1874, several observers have been directing their attention to the development of the Wolffian bodies and Müller's duct in these fishes. Mr. Balfour is the only observer who at present has published drawings of his discoveries. *Professor Semper*, of Wurzburg, has in the 'Centralblatt,' July 25th, 1874, a remarkable preliminary note, in which he announces the discovery in the embryos of several Elasmobranchs (Acanthias, Centrina, Scyllium) of a primitive series of apertures connecting the long Urnierengang (into which they are pushed) with the peritoneal cavity. These are identical with the involutions first described by Mr. Balfour, and are, according to Professor Semper, *ciliated.* Professor Semper then in a strange way for one who has so strongly repudiated "natur-philosophisch" speculations, declares that he has now furnished the proof of the genetic connection of Vertebrates with Annelids—the series of open ciliated funnels of the embryo Wolffian bodies being a series of "segmental organs," one corresponding to each metamer or somite of this region of the vertebrate's body. Professor Semper is not the first by any means who has seen that the genetic affinities of the Vertebrata are with an annelid-like invertebrate, nor is he the first who has clearly seen the relationship of segmental organs and the primordial vertebrate kidney.[1] Whatever modification of his earlier views may be necessary, it is to Professor Gegenbaur that the merit of this as of so many other fruitful suggestions is due (see his 'Grundzuge der Vergleich Anat.'). The discovery of this series of ciliated funnels makes it probable that the unsegmented character of the primordial kidney of Bdellostoma is due to the fusion of a series of distinct segmental organs, and not to the persistence of an unsegmented structure (like the notochord) from an unsegmented ancestral form. In his zeal to crush the teaching of the Jena school, Professor Semper declares that the Müllerian duct (Urnierengang), with the sides of which the Wolffian bodies with their funnel-like mouths appear *primitively* to have been connected, has nothing to do with the said Wolffian segmental organs. The comparison of the primordial kidney of Bdellostoma with the various conditions of these organs in

[1] Dr. Anton Dohrn, of the Zoological Station, Naples, has for some years been engaged in elaborating a theory of the "Annelidan Origin of the Vertebrata." The evidence in favour of such a view, which he has collected, is very much more extensive than that adduced by Professor Semper. A memoir on the subject, by Dr. Dohrn, will be published in January.

Fishes and Amphibia, seems to us to lead to the confirmation of Professor Gegenbaur's view, and we must look for some evidence on the subject of greater weight than what Professor Semper has at present advanced, before we can acquiesce in his controversial attitude. In a second paper in 'Centralblatt,' Nov. 7th, Professor Semper announces a still more important discovery, to wit, that these segmental organs, or rather the funnel-like mouths which establish a segmental character for the Wolffian bodies, *can be easily detected in many adult Elasmobranchs, e.g.* in the genera Scymnus and Squatina, also in Spinax, Centrophorus, Acanthias, Hexanchus, Pristiurus, Scyllium. In Squatina they are of large size and observable with the naked eye in fresh specimens. In his first communication Professor Semper, whilst holding the female genital duct to be a distinct secondary structure unconnected with the Wolffian segmental organs, was yet inclined to believe that the male genital duct took its rise in a modification of the funnel-like segmental organs. This he now declares to be erroneous, and inclines to the view that the common genito-urinary duct of the male is a new structure. He finds in young males, and even in some adults, a remnant of a tube with expanded internal opening, corresponding to the female genital duct. This either persists in a rudimentary state or disappears entirely; it is therefore clear, that the male genital duct is not precisely the same part as is the female genital duct in these fishes, since the male possesses both. In fact, as far as we can understand Professor Semper's statements, there is strong similarity with the disposition of these parts which prevails in the Amphibia, the primitive Müller's duct or original longitudinal canal of the primordial renal organ remaining in the female as oviduct whilst aborting in the male, and in both sexes a new duct develops, connecting the posterior end of the Müller's duct with the mass of the renal body developed out of the segmental funnels and their continuations. This duct, by a connection of part of the segment-funnels with the testis (as epididymis) becomes both genital and urinary in the male. Without illustration and fuller explanation, it is not possible to arrive at a clear apprehension of Professor Semper's facts; but it is obvious that he has entered upon a most important research (already, we must repeat, broached by Mr. Balfour), the full details of which promise to be of exceeding interest for students of vertebrate morphology.

With regard to the bird's Wolffian duct itself (the appearance of which in the Chick precedes that of the Müllerian duct, though in Anamnia the reverse is the case, the Müllerian duct being there the first vestige of the uro-genital apparatus of tubes, from which all the others appear to bud, or into which they are pushed), *Balfour* and *Foster* (loc. cit) maintain that it arises as a ridge at about the thirty-sixth hour, projecting from the mass of uncleft mesoblast on the outside of the protovertebræ into the triangular space covered in by epiblast above. This ridge becomes hollow by its cells acquiring a radiating arrangement around the commencing lumen. *Waldeyer* held that the lumen was formed by the closure of two ridges ('Eierstock und Ei,' 1870). *Romiti* ('Archiv f. Mikroskop. Anat.,' 1874) describes the Wolffian duct as being formed by an involution of the epithelium of the pleuro-peritoneal cavity, in the form of a longitudinal groove, which speedily closes in, and looses its communication with the pleuro-peritoneal cavity. According to Foster and Balfour this is certainly the way in which the Wolffian duct is formed in Amphibia and osseous Fishes, and this makes them receive Romiti's statements with the greater caution.

Dr. Alex. Schultz, of Strasbourg, in the 'Centralblatt' of Oct. 31st, states that he has observed the same facts in embryo Torpedoes as those recorded by Semper for Sharks. A primitive longitudinal canal—the Müllerian duct or Urnierengang—is observed, into which a series of funnel-like openings make their way, so as to connect the long duct at intervals with the peritoneal cavity. Each funnel corresponds accurately with the limit between two proto-vertebræ.

Schultz differs with Semper as to the male genital duct. He declares that this develops directly out of the Müllerian duct (Urnierengang) without intervention of the funnel-like organs or their continuations. It is not clear from the papers above cited what is the *precise* significance given by various authors to the terms Urnierengang, Müllerian duct, Wolffian duct. It would be well, in the present state of the question, to abandon these terms, and use others which have no implication.

E. Gasser has published, at Frankfort, a graduation thesis *On the Development of the Allantois, the Müllerian ducts, and the Anus.* His observations relate to the Chick. He states that the Müllerian duct makes its appearance on the third day of incubation in the form of a short groove, between the already existing Wolffian body and the Hautplatte. This closes up and forms a funnel, the narrow end of which grows towards the anus. There is never a union of the Müllerian duct with the duct from the Wolffian body, at the posterior part, as His maintained.

Gasser is in agreement with Waldeyer (Eierstock and Ei), who is also followed by Balfour and Foster in their work on the Chick, noticed above; but Gasser differs from these authors in denying the junction at any time of the Müllerian and Wolffian ducts.

Sernoff ('Centralblatt,' June 27) agrees with Bornhaupt in considering that the duct of Muller (in the Chick) is formed by a simple involution from the pleuro-peritoneal cavity, which grows backwards in the mesoblast, between the Wolffian duct and the germinal epithelium; and thinks that Waldeyer is in error in supposing the involution to be in the form of an elongated furrow. Balfour expressed a similar view as to the mode of formation of the Müllerian duct in dog-fish (this Journal, October, 1874).

PROCEEDINGS OF SOCIETIES.

MEDICAL MICROSCOPICAL SOCIETY.

16th October, 1874.

New and expeditious method of Micrometry. By John Gorham, Esq.—The principle of the instrument described depended upon the measurement of lines drawn parallel to the base of an isosceles triangle—the base of the latter being given—by means of the sides, which are divided into a known number of parts. The triangle is obtained by dividing through the centre a disk of brass, about $1\frac{1}{4}$ in. in diameter and half an inch thick, and bevelled at the edge so as to allow of its being embraced by a stout india-rubber ring, by which means the two portions are held in perfect apposition at the edges of the section. The line of section for the distance of one inch from the circumference is marked out into fractions of an inch, at least into thirty-two parts, a less number being insufficient to obtain a minute result. A piece of paper of known thickness is now inserted between the halves of the disc and moved along till its edge touches the commencement of the marked inch, the elastic band retaining it in its place, and thus an isosceles triangle or gap is left with a base the thickness of the slip of paper, and with an edge of one inch divided, as stated, into thirty-two equal parts. If a hair or cobweb be passed along the slit from base to apex it will be arrested somewhere, and by reading off the number opposite which it stops—a simple matter of multiplication, the base of the triangle being known—will give the diameter required. For microscopic purposes the instrument is placed on the stage, and the object to be measured, placed on a thin glass cover, is slid over the aperture till it exactly at one point spans it; the diameter is then read off. To obtain still greater accuracy Mr. Browning has added a screw of known value to separate the halves of the micrometer in lieu of the slip of paper.

In answer to some questions by members of the Society, the President replied that the instrument was specially designed for unmounted objects, the thickness of an ordinary glass slide being rather an objection in the case of mounted ones; a thin glass cover might be in all cases employed for placing the specimen, *e.g.* blood or pus, upon.

20th November, 1874.

Ichthyosis Linguæ.—Dr. Goodhart has observed two cases, both men above middle age, both with a history of syphilis, and in both the disease ended in epithelioma; in one the ichthyotic condition had lasted ten years. The naked-eye appearance of the disease is that of a thick, hard, white coating to the tongue, in patches on its dorsum, and sometimes on the cheeks. In one case the patches were of the character of local warty excrescences, a millimètre in height, consisting microscopically of a number of vertically set papillæ, of fusiform shape and ragged surface; the surrounding epithelium was twice its normal thickness. In the plaque the epithelium was much thickened, as also the cutis vera and sublying fibrous tissue; at times the epithelial layer was of uniform thickness, at others it was seen dipping down to the interpapillary spaces and sublying fibrous coat, and was surrounded by a small cell growth; to all these changes the warty appearance was due. All this was explained by over-activity of the rete Malpighii, the supply of cells produced being greater than the demand created by wear and tear required.

He had not observed the colossal papillæ described by Mr. Hulke, nor the shrunken papillæ described by Mr. Fairlie Clarke, which latter might be explained by the normal papillæ having been cut obliquely; still, if the interpapillary depressions are for long clogged with excess of epithelium, then the papillæ would seem to be less prominent. The thickening of the subcutaneous fibrous tissue was especially noticed in the condensed fibrous band that normally may be seen running along immediately below the base of the papillæ.

The muscular fibre of the tongue had not been found diseased.

In order of sequence it was difficult to state which ought to be placed first, the epithelial growth or the excess of subcutaneous fibrous tissue, but probably the former.

The incurability of the disease might be owing to its being generally seen when almost in the condition of epithelioma. With regard to this latter affection it was hard to trace microscopically its exact relation to ichthyosis, the general infiltration of the subjacent fibrous tissue of an ichthyotic patch with indifferent cells indicating its presence; in fact, this condition was generally characteristic of epithelioma in this situation, it being comparatively rare to see the so-called bird's nests of epithelium. Even before the onset of epithelioma the greatest difficulty in treating an ichthyotic patch with the idea of curing it would be from the altered habit that the cells must have acquired after a long time, which would have to be counteracted before the normal state of things could be resumed. In ichthyosis the normal tissues were only in excess, but in epithelioma this was not only the case, but the epithelial cells infiltrated parts foreign to them, and from their very rapidity of growth acquired the characters of "indifferent" cells. A second condition rendering the cure of ichthyosis doubtful, and at the present time impossible, was the increase of fibrous tissue. At first excessive epithelial growth was found; this meant increased blood supply, and this in turn increased development of tissue supplied by the blood; hence the one condition reacted on the other.

The President discussed the paper generally, criticising the use of the term Ichthyosis; he thought that of Tylosis better. He had not had the opportunity of observing a case pass on to epithelioma, and quoted one where there was no history of syphilis.

Mr. Fairlie Clarke remarked he had, in adopting the term Tylosis linguæ, only reproduced the original name, and that there were strong arguments clinically against that of Ichthyosis. He had found microscopically a thinning and wasting of the papillæ, for not only is there increase of cell structure towards the surface, but it even dips down and spreads laterally, between the papillæ themselves; this especially appearing as it approaches the condition of epithelioma. Sooner or later an "ichthyotic" tongue became epitheliomatous, but there is a condition where white patches ("white fibrous cicatrices") are seen on the tongue, which, though incurable, does not lead to epithelioma, and hence requires carefully distinguishing from tylosis linguæ. Epithelioma supervenes in two ways—either by extension of cell growth from the surface, which growth not only is in large quantity but penetrates into tissues into which it is naturally foreign; or secondly, it may commence in the underlying structure as the result of prolonged irritation from the ichthyotic patch. Palliative measures may relieve in the disease, but as yet we are ignorant of any cure short of that by surgical interference.

Mr. Henry Morris discussed the connection of cancer and ichthyosis linguæ, remarking that though, in his opinion, quite distinct diseases, yet that both depend upon modified nutrition, this being the production of excessive epithelium in the case of cancer, heterologous, but not so in ichthyosis. He had observed, at least once, epithelioma follow, as a distinct result of irritation to an ichthyotic patch that had shed its scale, the red raised spot becoming a cancerous ulcer. Where epithelioma has followed, it does not spread more rapidly than if it had started quite independently, even though the ichthyosis may have been of long standing. He believed the disease to be like ichthyosis elsewhere; he had seen it on the tongue while the neck around was similarly affected.

Dr. Allchen asked whether the secondary conditions described were not rather extensions of the ichthyotic growth, and not true epithelioma, in a histological sense, although clinically malignant.

Mr. Needham, in two cases operated on where epithelioma was commencing, had observed hypertrophy of the papillæ and of the cutis, which was infiltrated with large granular cells. The vessels were also enlarged. He had traced the epitheliomatous growth to the original ichthyotic patch.

Dr. Goodhart, in reply, preferred retaining the term ichthyosis linguæ as one well understood now. Had but once seen the "white cicatricial patch" described by Mr. Fairlie Clarke; he did not think it cicatricial in character, for it could be scraped off, and suggested its being owing to some chemical change on the mucous surface. It was not the rule to find the "bird's nests" of epithelium in epithelioma of the tongue; but he had usually observed an abundant infiltration of small cells under the epithelium, as in ichthyosis linguæ. The second cause for cancer following this disease, given by Mr. Fairlie Clarke, was useful in explaining those cases where the direct extension of the disease from the original patch could not be observed. He had never verified Mr. Needham's observation of hypertrophied papillæ, though he had heard that condition described before.

Royal Microscopical Society.

May 6th, 1874.

Suctorial Organs of the Blowfly.—Dr. Anthony drew attention to the presence of certain "chitinous rings" or "arches" contained in a zigzag slit or furrow which passes down each of the pseudo-tracheæ, or quasi-tubes of the tongue. These rings keep the slit or furrow open, and were supposed to be concerned in suction.

Silica Films artificially produced.—In a former communication Mr. H. J. Slack had described a variety of beaded patterns that could be obtained by making the artificial diatoms of Max Schultze. Silicic fluoride gas is allowed to come in contact in its nascent state with cotton filaments moistened with water; the result is a deposition of silica in the shape of irregular vesicles, the walls of which exhibit beaded structures in definite patterns. If the gas is passed simply into water, the silica is deposited in amorphous particles, but by using a mixture of glycerine and water very delicate films are obtained which show a very complicated beaded structure: some have a striking though illusory resemblance to organic cell-forms, and even to bacteria and fungi. The size of the spherules is $\frac{1}{30000}$ to $\frac{1}{100000}$ of an inch.

On the use of Black Shadow Markings and a Black Shadow Illuminator.—The intensity and clearness of black shadows as seen with the microscope was recommended by Dr. Royston Pigott as a test of the excellence of the instrument. Some observations made on the spherules of silica obtained by Mr. Slack's process were described, and reference was made to the black shadow illuminator constructed by the author in 1864.

June 3rd.

The secretary drew attention to a slide exhibited by Mr. Baker, just received from Herr Möller, and a very remarkable specimen of his skill. In a square with sides only $\frac{1}{10}$ of an inch were eighty clear circular spaces in a dark framework of photography, and in each space a fine specimen of a diatom with its name plainly photographed below it. The whole series could be well seen under a $1\frac{1}{2}$ in. objective, and the names read. It was stated that Herr Möller had prepared slides with 100 as well as those with eighty specimens, and was about to introduce similar slides of *Echinoidea*, *Holothuridæ*, &c.

Position of the Touch Corpuscles in the Human Skin.—Mr. Charles Stewart's attention had been drawn to the subject by a paper written by Dr. Thin, and though he agreed generally with that writer as to their structure, he could not altogether agree as to their position. The results of his numerous observations showed that they were invariably situated in those papillæ which were nearest to the furrows of the skin, and never in those nearest to the sudoriferous ducts.

October 7th.

Supplementary remarks on the Appendicularia.—The remarks referred to a species of the genus *Oikopleura*, to which, though it appears to be new, Mr. Alfred Saunders has refrained from giving a specific name. The author adopts the nomenclature with regard to the position of the body originally used by Professor Huxley, in preference to that of Dr. Fol and M. Vogt of Geneva. The author describes successively the integument, digestive system, nervous system, and heart, referring to the observations of Dr. Fol. With reference to the heart he finds it to be composed of several longitudinal fibres attached anteriorly along a transverse fibre, these fibres being apparently not united together by a membrane. At all events, the wall next the stomach is deficient, neither is there a cell present at either end. Mr. Ray Lankester's opinion, therefore, that the heart is a mere churning organ, is so far confirmed.

New diatoms from Panama.—Mr. F. Kitton characterised the new genus *Perrya* (Kitton) as follows: "Free, elongated, frustules compressed, sometimes slightly constricted, extremities rounded, striæ transverse, moniliform, marine." This genus is distinguished from *Nitzschia*, which is its nearest ally, by the absence of a keel, and also by its very much compressed valve.

Dublin Microscopical Club.

25th June, 1874.

Navicula gemmata, var. *biseriata*, Grunow = *Navicula spiralis*, O'Meara, *exhibited*.—Rev. E. O'Meara exhibited some specimens of *Navicula gemmata*, var. *biseriata*, Grunow, mounted by our corresponding member, F. Kitton, Esq., of Norwich. Mr. O'Meara considered the form identical with *Navicula spiralis* exhibited by him at the meeting of the Club in August, 1871, and so named by him. At this time he had not seen Grunow's work, 'Reise der Novara,' published 1868, and in which this form is described; if, indeed, the figures left any doubt on his mind as to its identity, the inspection of the example kindly supplied by Mr. Kitton had completely removed it.

Section of Spine of Diadema setosum.—Mr. Mackintosh showed a section of the spine of *Diadema setosum*. These spines are long, hollow, and strongly serrated; in section the central cavity is seen to be surrounded by a thin, dark-coloured ring, from which a series of slight solid pieces are given off, which, at first narrowing, afterwards expand into long isosceles-triangle-shaped segments, pale yellow in colour, and about equal in length to the diameter of the central space. The bases of these triangles are rounded, and form the longitudinal ribs, which project from the surface of the spines, and irregular bands of solid material pass from one ray to the other, sometimes exhibiting foramina.

Human Hair presenting a remarkable alternate transverse dark and white Mottling.—Dr. Frazer exhibited a quantity of female hair of considerable length (upwards of thirteen inches), which was lately sent to a hairdresser in this city for manufacturing purposes, and found useless; it was reported to be "Italian hair." Every separate hair was finely marked with alternate white and dark brown colouring, so that, although the entire mass, at a short distance, was of a dark brown or brownish-black colour, a closer inspection showed that it presented the remarkable transverse mottling described. The white interspaces were very small, but occurred with strange uniformity along the entire length of the hair from end to end. As the mass had been cut off, it presented no roots, but the linear markings extended up to the point of removal. On measuring some of the coloured parts it was ascertained that a space of $\frac{1}{8}''$ covered five separate tints of hair—three white and two dark coloured. The tints shaded into each other if examined closely, but the change of hue, examined at a slight distance, appeared abrupt and complete. The hair was moderately coarse, but otherwise of good quality; all its physical and microscopic characters were those of ordinary human hair. Of course, no history could be procured of the specimen, which, so far as Dr. Frazer's information extended, was unique, approximating closely to the hair of some animals in coloration.

Intestinal Glands of Mouse.—Mr. B. Wills Richardson exhibited a doubly stained piece of the intestine of a mouse, and observed that in recently making some nitrate of silver and carmine stainings of both the (so-called) endothelium and epithelium to be found in the abdominal cavity of that animal, some of which stainings he had brought before the Club at its last meeting, he found that its intestine, when successfully stained and laid open longitudinally and carefully pencilled out with a sable brush, afforded some very instructive specimens illustrative of its glandular supply. In the specimen now shown the walls of the alveoli for the little intestinal glands, which walls were chiefly formed of connective tissue, were stained slightly brown by nitrate of silver, the glands themselves being well coloured by the carmine fluid. Here and there in the specimen a gland had been pencilled out of its alveolus, which, of course, was empty. Since he had mounted the specimen under exhibition he had succeeded in separating the muscular wall from the mucous membrane of the remainder of the stained piece of the intestine. This wall is composed of two distinct membranous layers of organic muscle, the fibres of one layer running in a circular, and of the other in a longitudinal, direction. It might be of some use if he mentioned that nitrate of silver staining is liable to be obliterated by the ammonia of the ordinary carmine stain, and, therefore, it would be advisable, in staining tissues with nitrate of silver and carmine stains, to substitute potash for the ammonia of the carmine fluid. He had tried the potash, and found that it answered the purpose admirably. The potash, he reminded the Club, had a tendency to soften many structures, and, therefore, delicate objects should not be left too long in this potash-carmine fluid. This softening property, however, had its advantages, for owing, probably, to it, he was enabled to peel the muscular off the mucous coat with the assistance of a sable paint brush.

A Spirogyra with an Oscillatoria inside its Joints, presenting a curious appearance.—Dr. John Barker brought for exhibition a large (unconjugated) Spirogyra-form, having within several of its joints a minute *Oscillatoria* in considerable quantity, often densely crowded and always forming a spiral coil, the turns more closely set towards the ends of the joints. No visible openings were perceptible by which the *Oscillatoria*, which was the same as a form abounding in the gathering, could have entered, but such must have been present.

Abnormal Head of Trifolium pratense, exhibited.—Mr. Greenwood Pim, jun., drew attention to an abnormal clover head (*Trifolium pratense*), presenting the following aberrant characteristics. The vexillum was green and leaf-like, the calyx was normal, whilst the corolla (vexillum excepted) was reduced to mere scales; within was a whorl of small, but perfect flowers, elevated on a slight prolongation of the axis. The original flower appeared to have no pistil, and as the secondary flowers were nine in number, they appeared to replace the stamens; the tenth stamen appeared as a wart on the vexillum.

Œdogonium excisum, Wittrock et Lundell, *new to Britain.*—Mr. Archer exhibited (from Connemara), new to Britain, fertile examples of *Œdogonium excisum*, Wittrock et Lundell, a very minute species, but one so distinctly marked there could be no doubt as to its identity. He showed Wittrock's graphic figure, along with his excellent description, distinctly fixing the species. It may be possibly more common that might be *à priori* supposed from but a single Swedish, afterwards a single Austrian, and now a single Irish locality being recorded, but, of course, if met with in the sterile condition only, the identity could not be certain, and it must then, almost inevitably, be overlooked.

23*rd July*, 1874.

Constituents of Leinster Granite.—Professor Hull exhibited sections of Leinster granite from Killiney, showing, when viewed under polarized light, that two felspars are present, a monoclinic and a triclinic, besides the quartz and mica. Judging from the analysis of the granite made by Professors Haughton and Galbraith, which in all cases showed the presence of soda, Mr. Hull concluded that the triclinic felspar must be albite. This mineral had only once been previously detected, viz. by Dr. Westropp in a specimen at Kingstown, but, judging by the sliced specimens from several localities, Mr. Hull concluded that albite was always present in the granite in small proportion and was an essential constituent of it.

Navicula Heufleri, Grunow, *N. hungarica* and *N. fulva*, Nitzsch, *exhibited.*—Rev. E. O'Meara exhibited examples of the foregoing. The last, as Donkin properly observes, strongly resembles *N. cuspidata*, but is distinguished from it by the character of the striæ, which are oblique in the former, whilst in the latter they are parallel. All these forms were found in a gathering made by Rev. M. H. Close at Lough Gill, Co. Kerry.

Muscular Wall of Intestine of Mouse.—Mr. B. Wills Richardson exhibited a slide containing a preparation in glycerine of the muscular wall of the intestine of the mouse. A portion of the intestine was immersed for several days in Beale's carmine fluid and glycerine; potash, however, having been substituted for the ammonia. With a moderate-sized sable brush he was then able to pencil the muscular wall off the mucous wall of the bowel. Pieces of both walls were then mounted as permanent preparations. A mounting of the mucous wall he had exhibited at a previous meeting of the Club. As potash had a tendency to soften many structures, they must not be allowed to remain too long in it lest they should be spoiled. Mr. Harry Draper substituted the potash for him (Mr. Richardson), as it has little, if any, tendency to destroy nitrate of silver stain.

Actinophrys digitata, Dujardin (?), *exhibited.*—Mr. Archer showed some examples of the rhizopodous form, most probably *Actinophrys digitata*, Dujardin, both in the natural condition and stained by Beale's carmine solution, and drew attention to the fact that no nuclear structure seemed to be manifested. This form, which, indeed, he thought could hardly be regarded with the well-marked *Actinophrys sol*, he had several times so treated, and always with the same negative result. It is a very inert, but at the same time a *hungry* form.

17*th September*, 1874.

Foraminifera from Flint-nodule.—Rev. E. O'Meara submitted to inspection a slide containing a great abundance of various species of Foraminifera found in the central cavity of a flint nodule from the chalk rocks in the vicinity of Belfast. He was indebted to the kindness of Mr. Wright, of Belfast, for the material, which looked like disintegrated chalk, appearing likely to contain Diatomaceous forms, but none were found.

Eozöon canadense (two specimens), prepared by Dr. Carpenter and sent over by him for the Dublin University Museum, were exhibited by Professor Macalister.

Gonium pectorale in vast numbers, forming a very pretty object, was shown by Mr. Crowe.

Phyllactinum guttatum was shown by Mr. Greenwood Pim, jun.

Structure of Spines of Echinometra lucunter.—Mr. Mackintosh exhibited transverse sections of spines of *Echinometra lucunter* which appears to possess spines of two different forms. The greater number of them are conical and show in section the typical Echinometran structure, *i.e.* a central reticulation from which proceed rays, expanding at intervals into larger areas composed of a network with moderately wide meshes, joined by transverse bars going from ray to ray; the intervals opposite to the constricted part of the rays are occupied by solid pieces exhibiting the faint striæ so common to, if not characteristic (?) of, these structures. The expanded portions of the rays become shorter and relatively wider as they approach the circumference, and form globular expansions just before terminating in two or three branches going to the notches which form the longitudinal grooves of the spine. The other form of spine is club-shaped, ending in a short point, and differs in structure from the conical ones in that the rays gradually expand for about two thirds of their length, then contract and end at the circumference, somewhat as in the other spines, short, solid, striated pieces being placed between their extremities. Mr. Mackintosh had sometimes found the same structure in spines which were more cylindrical than club-shaped, and required a careful inspection to distinguish them externally from the ordinary conical spines, and this condition appears to be the normal one in *E. oblonga*.

Structure of "Baked" or Indurated Slate.—Professor Hull exhibited a thin transparent section of "baked" or indurated slate from the Silurian beds near Dundalk. This specimen had been originally ordinary clay-slate, but had been hardened by contact with trap-rocks, so as to resemble "Lydian stone." It was seen under the quarter-inch objective that the constituents now consisted of minute grains of silica cemented by a colourless glass or uncrystalline felspar, which contained black grains, probably of magnetite; these black grains imparted a dark shade to the stone. Mr. Hull believed that the argillaceous components of the slate (the alumina, &c., and lime) had been sufficiently heated to undergo fusion, but the original grains of silica remained unaltered and were now bound together by a glassy cement, which sufficiently accounted for the superior hard-of the "baked" over the unaltered slate.

A New Bat-tick.—Mr. R. M. Barrington exhibited a specimen of a bat-tick, *Ixodes scotophili*, a new species found by him on *Scotophilus Leisleri* (taken in Co. Armagh in some abundance, an interesting fact in itself).

Chlorochytrium Lemnæ, Cohn, *new to Ireland.*—Mr. Archer showed the new parasitic alga lately described by Professor Cohn ("Ueber parasitische Algen," in 'Beiträge zur Biologie der Pflanzen,' p. 87, t. ii; also 'Quart. Journ. Micr. Sci.,' Vol. XIII, N. S., p. 366), which inhabits the fronds of *Lemna trisulca* and named by him *Chlorochytrium Lemnæ.* These examples were found lately in some pools at Raughlan, close to Lough Neagh, near Lurgan. This was the first record (Mr. Archer thought) subsequent to Cohn's of the occurrence of this remarkable and, in its bearing, highly interesting little alga; it is probably, however, not uncommon, though Mr. Archer had looked for it since the publication of Professor Cohn's memoir, but without success until the present occasion. Prof. Cohn's examples were met with by him in some examples of the *Lemna* kept in a room over winter, and upon examining them in the month of May. Those now shown were met with in the open field and in the month of August.

15*th October*, 1874.

Examples of Irregular Sessile Foraminifera Structure exhibited.—Professor Macalister, M.D., exhibited several sections of the remarkable irregular sessile rotalian genus *Polytrema* from the shell of *Tridæna*, and others from the tube of *Chætypterus.* The sections, both vertical and longitudinal, exhibited the foraminiferous nature of this form, which had been described by Lamarck as a *Millepora.* One of them also exhibited a tubular intercameral canal, like the stolon canals of *Orbitolites*, with a section of which it was contrasted.

Some Diatoms from Antarctic Sea exhibited.—Rev. E. O'Meara brought under notice some slides mounted by Mr. Carter from material collected in the Antarctic circle. Though not put up for the purpose of finding Diatomaceous forms, still several species of great interest were found, some specimens of *Coc-*

coneis regalis amongst the number. He called attention to a very pretty discoid form, which occurred in tolerable abundance, and which was new to him. The slides being mounted and covered he could see them only in one aspect, and, without being able to examine them more fully, could not decide as to their genus.

Structure of Spines of Centrostephanus longispinus. — Mr. Mackintosh presented transverse sections of the spines of *Centrostephanus longispinus*, which showed the usual dimorphic structure already described in connection with *C. Rodgersii*, from which the present specimens differed to a distinctly appreciable degree, whilst presenting manifestly a generic similarity. It appeared not unlikely that the species under consideration would yield spines intermediate in structure between the conical and fusiform condition, and he drew the attention of the Club to the remarkable effect of injury to a conical spine which had the result of producing a reticular structure, only differing from that in the fusiform spine by its greater irregularity.

Structure of Tail of Basking Shark.—Dr. Steele exhibited a section of a portion of the inferior lobe of the tail of the "basking shark." The substance of this portion of the tail is traversed by a vast number of closely-set parallel "bristles." Each of these is about 6—8″ long, about a millimètre in thickness, and when freshly removed from the surrounding tissue is brilliantly transparent. To obtain a satisfactory transverse section a portion of the tail must be allowed to dry, when it may be cut by the ordinary slicing instrument. When moistened with water the section may be examined with a low power. Each bristle thus appears to have a central canal, surrounded by concentric layers like hair or an *ossicle* in bone. If the section be steeped in alcohol, so as to remove the water, it may be at once mounted in balsam. It forms a pretty polarising object.

Conjugated State of Pinnularia hemiptera.—Dr. J. Barker exhibited the conjugated state of *Pinnularia hemiptera* at the stage when the two "sporangial frustules" were just formed, and, as is usual, of twice the linear dimensions of the parents, the wall being transversely corrugated, as occurs in *Navicala serians*, *Stauroneis phenicenteron*, and others, which, when thrown off, the young frustules would assume the characteristic form of the species; as reminded by Mr. O'Meara, Dr. Pfitzer records this species being seen in conjugation by Schumann in 1870; still a sight of almost any diatom in conjugation is a rarity.

Section of Cirrhosed Liver exhibited.—Mr. B. Wills Richardson exhibited some stained sections taken from an extremely cirrhosed liver of a man who died in the Adelaide Hospital. In the specimens exhibited the bands of lymph were almost the only parts stained by the carmine fluid, so that they contrasted remarkably with the compressed and atrophied glandular structure which occupied the spaces mapped out by them. The man was an inordinate whisky drinker.

Encysted Condition of Uvella.—Referring to the observations made at the Club meeting, February, 1871 ('Quart. Journ. Micr. Sci.,' Vol. XI, N. S., p. 316), as to the possible relationship of *Synura*, *Syncrypta*, and *Uvella* (Ehr.), with the marine form *Magosphæra*, forming the type of Häckel's *Catalacta* ('Biologische Studien,' p. 139), Mr. Archer now presented examples of the common *Uvella* in an encysted condition, quite parallel to the same state of *Synura* and *Syncrypta*, and conjecturally also of *Magosphæra* itself. Here the little encysted constituent "monads" formed a group, each now quite globular, rather thick-walled, the contents bluish, very refractive, and each invested by a special outer covering (standing slightly away from the wall), this quite hyaline but rather coarsely granulate. No "amœboid" phase had yet been noticed. A nearly similar encysted state occurs in *Dinobryon sertularia* (specimens were shown) and there is no doubt a certain "affinity." In the forms *Syncrypta* and *Uvella* (are they truly *generically* distinct?) the monads radiate from a common centre; in *Synura* they terminate the ultimate branches of a dichotomously arborescent structure, starting from a common connecting piece (like two trees growing in opposite directions, with a common trunk, but no roots); thus as regards the dendroid stipites there is a certain amount of bilaterality sometimes even expressed by a greater or less indication of a figure-of-8 shape of the outer circumference of the colony. But in *Dinobryon sertularia* the monads exhibit a dichotomously branched "polypidom" starting from a single basal point; however, in the "quill-like" *Dinobryon* noticed by Mr. Archer before the Club, April 16th, 1868, the tubular "urceoli" of this structure radiate with a "fan-like" sub-hemispherical outline from a common centre. Thus though the present be but an isolated little note, it might have possibly some bearing on the question of the true nature of these organisms.

Prothallus of Fern, with Scalariform Ducts, exhibited.—Mr. Archer exhibited a preparation from Mr. James Abbott, communicated by Professor Thiselton Dyer, of a prothallus of an unknown fern, showing scalariform ducts, as first drawn attention to by Dr. Farlow. The ducts were very readily seen, in one example forming an elongated bundle, and in another in the condition of but as yet ordinarily formed cells with the scalariform deposit. No rudiments were evident in this specimen of the primordial asexually produced leaflet or rootlet, as described by Dr. Farlow, the position which such occupies, near the sinus of the prothallus, being quite empty.

MEMOIRS.

On CHLAMYDOMYXA LABYRINTHULOIDES, nov. gen. et sp., *a* NEW FRESHWATER SARCODIC ORGANISM. By WM. ARCHER, M.R.I.A. (With Plates VI and VII.)

SOME short time after the appearance of Cienkowski's memoir on a new type of Sarcodic organisms met with by him in the sea (at Odessa), which he named Labyrinthuleæ, I was not a little surprised and interested on meeting with a form from the freshwater so wonderfully resembling those described by him, as, notwithstanding one circumstance, hereafter to be adverted to, even still to render it a matter of considerable question whether it may not truly belong to that group, even though it should not be congeneric with the typical Labyrinthula (Cienkowski).[1]

I regret indeed that, after repeated efforts to learn more of its development or history, I have but little succeeded, except so far as knowing that it is an endo-parasitic growth, at least for a portion of its existence.

It will, perhaps, be the best course to endeavour first to give an idea of this curious production as it exists, before referring to Cienkowski's forms, which would, indeed, be necessary previous to comparing or contrasting it therewith, or with any other simple organisms evincing any similarity in minute specialities.

The component elements of the present form, broadly taken, are primarily divisible into two—the inner soft sarcodic body-substance, or the contents, and the outer rigid cyst, or envelope, which nearly constantly surrounds the former.

But neither of these are quite simple, especially the former, which presents a variety of constituents.

To advert briefly in the first place to the latter, or the outer coat or envelope, its complexity consists, indeed, only in the number of similar layers of which it is composed and its great irregularity of outline. It is often very thick, according

[1] Cienkowski: "Ueber den Bau und die Entwickelung der Labyrinthuleen," in Schultze's 'Archiv für mikr. Anatomie,' Bd. iii, p. 274.

to the number of laminæ of which it is made up, but even the thinnest or such as possess but a single lamina would, on the whole, be called "thick walled" as compared with many vegetable cells. This wall is hyaline, and when viewed superficially it is colourless or nearly so, but when viewed edgeways or at the margin of a many-laminated example, where a considerable density is therefore seen through, it appears of a pale straw colour or brassy hue and extremely shiny and glossy. Its consistence is tough, requiring strong pressure on the covering-glass to burst it (Pl. VII, fig. 4). As mentioned, the outward figure is most varied; globose or broadly oval might, perhaps, be called the typical, but examples lobed in a variety of ways are extremely frequent. Nearly always, from one, two, or more places, are given off neck-like extensions of greater or less width, terminating in a lacerated manner; these are produced, as it were, by the prolongations laterally of a certain number, greater or less, of the laminæ composing the wall, and then as if abruptly torn off (Pl. VI; Pl. VII, figs. 3, 4, 5.)

Leaving the outer envelope for the present, and passing to the inner soft and plastic "living" portion, this is not a simple or homogeneous plasma or sarcode, but it is itself composed of several seemingly distinct elements. The first of these is the basic substance of hyaline character, forming the common connecting medium of every other element (except, of course, the outer cyst or envelope alluded to) when the organism is in what may be called its state of repose, a state in which seemingly by far the greatest portion of its existence is passed. But at times a far more striking and remarkable phase presents itself when further structural elements of the "living" portion or contents come to view, to which I shall advert in the order in which they would most probably attract attention of an observer examining an example in "good order" of this production for the first time.

Since I met with this organism, on the first occasion in a single pool in the Co. Westmeath, I have found it in several not very distant sites in Connemara, having since then learned to detect its presence in quantity by the reddish colour presented to the eye in the mass, in the dormant or encysted condition, so abundant does it eventually become in pools where it occurs. Upon the earlier occasions of taking it, indeed, the red colour was by no means so prominent a characteristic as it seemed to have rendered itself subsequently, but it was still a sufficiently striking feature.

In examples (especially as more lately taken) it is just this reddish colour which would likewise first attract notice under the microscope. This is due to a number of granules of varying magnitude, often rather large, but mostly very minute, with a dark outline and of a bright red colour (Pl. VI; also Pl. VII, fig. 2, to the right; fig. 4). These may be often present in some examples in great abundance, sometimes in others more sparse, sometimes very few, or they may be in some specimens all but absent.

Of the granular or solid contents besides the red granules others of a yellowish-green colour will attract attention. These are usually more minute than the larger of the red granules, but ordinarily surpass them in quantity, the red ones only rendering themselves more conspicuous at first and in the mass by their brighter and therefore more striking colour. The fewer the red granules the more abundant the green, and *vice versâ*. These green granules resemble much the chlorophyll-granules of certain algæ, though never of a grass-green, but of a yellowish hue. I suppose it must be very probable that the red granules are in reality produced by change of colour of the green (Pl. VI; Pl. VII, fig. 2, to the left; fig. 4).

But in the formation of the " contents " yet another granular constituent has a part. Besides the above-mentioned red and yellowish-green granules, minute homogeneous looking rounded little granules occur, of a pale bluish tint (Pl. VI).

When wholly encysted, and now in a completely dormant and quiescent condition, the organism appears very densely filled, and hence the larger examples are quite opaque.

The first and second year of my noticing this organism in examples from the Co. Westmeath pool, quite frequently—since then from that site, as well as Connemara, very rarely—did I succeed in obtaining a view of the condition now to be described. It was therefore well to have secured the accompanying drawing, when the examples were readily found in suitable order.

Notwithstanding the seemingly tough consistence of the wall, or envelope, in manipulation, the contents have the power to burst or force their way outwards through it, and the basic plasma pours itself forth, bearing with it the granular contents as described, but not any of these escape or become scattered, for they are held together by the common medium, but, on the contrary, they pass onwards with it and soon a remarkable sight presents itself. The plasma, thus become extended and spread out over a space so much greater than when it occupied the cavity of the envelope, now shows the contained granules mutually much further apart, rendering the hyaline connecting basic medium in itself more apparent. This does not seem to form a border, or any "ectosarc" region; the contained granules stand close up to the outer contour, leaving no hyaline margin. In examples presenting this condition in a well-expressed manner (Pl. VI), I think I see yet another constituent of the basic substance, different from the common hyaline matrix—a kind of greenish, plastic, amorphous substance, as it were comparable to "diffused" chlorophyll, seemingly distinct from and yet, as it were, combining at the margins (if one may use the word) of the patches of it, with the hyaline matrix, than which, however, this substance appears to be of a less fluent or yielding nature. I do not think it would be capable of detection unless in examples so, as one might say, "on the stretch." Now, a beautiful play of quite globular pulsating *vacuoles* is seen to take place in the basic mass; these vacuoles, though very numerous, never become distended very large. It is very interesting to watch their alternate diastole and systole, now here, now there, distributed all over the extended mass; but, to see this properly, attention should be confined to a single vacuole. It is curious to observe a vacuole originate in the middle of a layer of the greenish substance adverted to—the vacuole expands for a time in the usual manner, but as if the expansion took place too vigorously in proportion to the yielding capacity of the surrounding substance, the latter becomes somewhat suddenly, as it were, *cracked* or *split* at opposite sides of the globular vacuole, the rift extending to a length, perhaps, as great as the diameter of the vacuole; anon the contraction abruptly sets in, and the divided surrounding substance *reunites*, and the rift becomes obliterated (as it were re-fused), perhaps not to return, even should the vacuole reappear in the same place (Pl. VI. See the vacuole in centre of the subtriangular outlying portion of plasma to the left).

But, as we watch, attention will soon be drawn off from the vacuoles. The first issuing portion of contents, upon being some time advanced into the surrounding water, forms, as it were, a primary trunk, which soon subdivides into a number of branches which taper off, or after tapering a little may again become expanded, forming a "peninsula" of the extended body-substance; or the connecting "isthmus" may disappear, leaving an "island" formed of the sarcode-substance lying apart. Presently, issuing from various parts of the "trunk" and principal "branches," as we have seen abounding in vacuoles, are soon noticed ramifications, extending far and wide in the most complex manner, *of filiform, hyaline, quite colourless threads of extraordinary tenuity*. These *ex-*

tremely delicate processes are flexible, but do not seem spontaneously to alter much in position as first developed, or at least very slowly, but only to grow in length and number. But, further, *pari passu* with their own appearance, occur at various distances upon them *minute fusiform bodies* of a pale bluish tint, their longitudinal axis posed in the direction of the length of the filament. At first glance these might momentarily be taken for so many fusiform expansions or enlargements of the delicate filament itself, offering a degree of (bluish) colour, owing merely to their greater thickness. But a closer inspection at once dispels this idea: *the fusiform bodies are seen to be in motion, though slow, along the hair-like filament* (Pl. VI, passim).

A very few minutes' examination suffices to prove this. I regret I have not a note of their rate of progression; but if attention be bestowed on any few spindles (four, five, or six), at any given place on one of these capillary filaments, their relative distances will be noticed to have considerably altered in a few minutes. The little spindle, now in advance of several others, may slacken its pace as compared with those behind, or, what comes to the same thing, the hindermost may become accelerated; the natural result is that the foremost spindle is overtaken; it may then act as a temporary stop or barrier to the advance of those behind, and the little group may come to a standstill. They may then remain in linear sequence, or become, as it were, huddled together, and form a little cluster, but by-and-by they may resume their movement. But in such a case of a spindle now in advance becoming checked, what is more singular may sometimes happen—the hindermost may actually *creep over the lazy one in front*, and, this accomplished, then, nothing baulked, quietly pursue its way, leaving the spindle previously in advance of it far behind.

It is natural to speak of these minute travelling bodies as *spindles*, for that is their usual shape, but this can vary. In such a curious case as that just mentioned, of one of these bodies passing right over another in advance of it sooner than allow it to remain a barrier to its progress, the former may assume a rounded or even a globose figure during the accomplishment of the act. (Its *sluggish* motion, and its often somewhat *slug-like* figure, as it slowly passes up and over its predecessor, seemingly at a standstill, might fancifully suggest a pair of *slugs*, unable to do more than creep, making an effort to accomplish between them but at best a very tardy game of "leap-frog"!) But when the little travelling body has passed over the other the fusiform figure is resumed. But normally, during progression, these bodies may sometimes represent rather a semi-fusiform figure, that is, one side may be *rectilinear,* this latter, when presented, being the side applied to the capillary filament upon which it travels, and the convex side raised up therefrom. During progression a still greater alteration of figure from the ordinary fusiform may present itself when one of these bodies arrives at a *fork* of the filament; then, as it were uncertain as to which route it ought to take, it becomes itself bifurcated, and one leg follows one branch of the filament, the other leg the other branch, and so the little body, now triradiate, may for some time remain stationary, as it were, *astride* upon the bifurcation.

These little eminently plastic bodies (one might roughly compare one to a piece of glazier's *putty*, or to *dough*) are, in fact, *identical with the little rounded or globular bluish homogeneous looking little granules in the central mass* to which attention was at first directed, and which are *distinctly fusiform only when upon the capillary filaments*, although, indeed, before they arrive there they may, some of them, appear elliptic or subfusiform. That they are really one and the same thing, notwithstanding the difference of figure between them as a rule, is seen by watching the rounded granules deliberately proceed out of the general central mass and pass up along one of the filaments; as soon as it has done so and begins to travel upwards, the globose figure is lost and the fusiform outline is assumed. Soon follows another and another, in just the same manner, and a more or less long *cortége* begins its curious procession. By-and-by some of the little bodies may retrograde, remain stationary, or again advance, or all may become drawn in, capillary filaments and all, and the whole become reabsorbed into the great central mass. When one of the little spindles returns from its journey it passes down from off the capillary support and *reassumes a globose figure,* and joins the rest of the similar granules within the central mass.

It is when a great ramified *tree* is thus formed, under the observer's eye, perhaps in ten or twenty minutes, and numerous capillary filaments spread in every direction, up and down and laterally and round about, these well laden with *spindles* and the central mass thus thinned out and wide spread and relieved of so great a proportion of the granular contents, that the beautiful play of vacuoles referred to can be seen, and the whole object presents a spectacle, in its way, of unusual and exceeding beauty (Pl. VI). It must be borne in mind that the example figured, amply furnished with ramifications, and with a tortuous "labyrinth" of filaments, as it is and well laden with spindles, as it appears, after all merely, represents what could be seen in a *single focal plane*, whilst, perhaps, ramifications sufficient to make up several such complex "trees" occur in different planes between the slide and the covering-glass, and which can be made out by focussing up and down, all appertaining to the single main trunk and derived in a brief period from the great common central head-quarters; nay, sometimes a secondary *colony* may be carried outwards and left apart at some remote point of the field, this latter now itself giving off minor branches and filaments back towards the *metropolis*. (See the more distant portion of Pl. VI.)

We have seen that these little bodies are of a homogeneous consistence, of a highly plastic nature, and of a bluish hue; they further appear to have no wall or envelope, that can be detected; they do not mutually coalesce, and, however intimately they may be temporarily applied, a close examination will show their individual contours. I have not been able to see any subdivision of them. Their motion is a gliding one, and, as has been seen, it is alway very gradual and easy, though sometimes slower, sometimes quicker, without any apparent rule or reason. Just as little rule or reason is evident in the course taken by the individuals, now of one and the same file—one may go the "main road," the other following it may take a "byway." Some reason, so far as it goes, appears why some should travel up the filaments and others remain behind in the general mass, in that it is seemingly just those which are most external, therefore nearest the place of origin, that is the base, of the filaments, which betake themselves thereon for the journey.

But if the variable rate and direction of the movement of these bodies be inexplicable, even still more enigmatical appears the cause, or the *modus operandi*, of the motion itself. One might suppose, indeed, that, once upon the filament, its elongation would cause the separation of the bodies and give rise merely to a seeming progression one from another. But we have seen their motion is a *real* one, and, in fact, automatic. They "spontaneously" leave the general mass, and, ascending the filament, commence their onward progress, and the latter, when once projected, seems to be even somewhat rigid, and incapable of imparting to them any impetus. The cause of the motion would seem, therefore, to reside in the spindles themselves: they are very plastic—they must seemingly be very contractile. But as they gently and smoothly glide onwards, as if without effort, and free from interruption, no very perceptible change of figure from the spindle-form is usually seen, except the flat side occasionally, or the furcate form more rarely, both as before adverted to. In the case of two flattened spindles, they may sometimes be seen gliding at opposite sides of the filament, and one may pass the other with the filament between, and now without any change of figure, unlike what occurs when two or several meet at the same side and cluster together.

Not less curious is it again, seemingly, *how these little bodies remain upon the filament.* What power keeps them there? They never seem to glide off or to be met with in the water around. In fact, these little performers on the "slack rope" seem to *hold on* admirably—but then their action is *very* deliberate!

I have sometimes supposed that, surrounding *both* spindles and filaments, a very subtle and delicate sheath, or envelope, must exist, of some amount of contractile power, whose action might exercise a propelling force to urge the spindles along the median axis, or, at least, to act as an auxiliary in conjunction with their inherent contractile locomotive power. Under a very high amplification indeed I have thought to have seen such a delicate envelope, but I cannot say that the appearance might not have been due to an optical illusion.

However, such a structure would not be without parallel in certain Helizoan Rhizopoda, for instance, *Actinosphærium Eichhornii,* in which the radiating pseudopodia possess a central axis of firmer consistence (surely not comparable to a spicule), covered by a softer sarcode envelope, certain granules passing between, evidently carried passively by the latter. But the movement of the spindles, consisting, as it does, of a quiet and smooth glide, is of different character. The axis of the pseudopodium of Actinosphærium, comparatively speaking, is a much coarser object than the delicate filament upon which the spindles travel in the present organism, and the soft involving granular sarcode of the former is indeed a very palpable thing as compared with the very subtle sheath assumed to possibly exist in the latter.

There exists a certain minute rhizopod, of which I have seen but very few examples, and have therefore had by far too restricted opportunity to study it to give an account of or to describe it. *It is there*, however, and even, as is probable, I may not myself be so fortunate as to re-encounter it, it will most likely be found by other observers, and far better treated of. For the present purpose it is enough to mention that this form is of an orange or buff colour, globose its "normal" figure, but is capable of much alteration of outline, and it is furnished with numerous linear pseudopodia. Now, the point worth mentioning here is that it possesses the power to eject with force, and rapidly, a considerable number, or (one might say) to "fire off" a simultaneous "volley" of its own orange granules, from all round its periphery, to a distance equal to the length of its pseudopodia, and with an amount of energy and consentaneousness which is truly surprising; no sooner, however, have the granules reached a tolerably equidistant limit from the periphery than they begin to return, but, by comparison, much more slowly, and they become reabsorbed into the general central mass. This curious action I have happened to see on only two or three occasions, and under only a low power; I, of course, immediately turned on a higher power, but the performance so rapidly accomplished was over, nor would the perverse thing repeat it. Other similar forms evince comparable phenomena in a less pronounced degree. But the question comes up, how was this remarkable action effected? The little balls were suddenly ejected and gradually retracted, each in a quite straight radial line; they must have been held in by *something*, or they would be shot off beyond recovery, either by a minute special cord of sarcode, rapidly evolved and again gradually retracting, or they must have passed either in or along the linear pseudopodia. If they passed up the middle of the pseudopodium it must be capable of great distension, or, if upon the pseudopodium, they would seemingly be thrown off beyond retrieval, unless (like Actinosphærium) there were a subtle enclosing sheath over a central axis to keep them in. Whether then it is possible to compare the *modus operandi* of the rapid movement of the round orange granules of the rhizopod alluded to, if on the pseudopodia, with the slow gliding action of the "spindles" on the filiform threads in the present organism, may be a matter of question.

Not less singular and curious than the spindles are the filamentary tracks upon which they travel. There is no perceptible difference in their width, or rather tenuity, near the great main trunk, or at the remotest extremity, nor after a ramification. The main trunk and the branches differ in size, as has been said, and a *branch* may become so small as to show the contained granules, evidently *within it*, in single file, and even of that degree of slenderness it is still recognisable as a branch, and it is at least as wide as a single granule or spindle. But the filamentary tracks proper are (by comparison) much narrower than the spindles, appear like delicate "silvery" lines (eluding observation sometimes, owing to being out of focus), and they do not give the idea of having the spindles *in* them (as does the finest branch) but *on* them, even when doubtless they are upon its upper or lower side, in relation to the observer. They are given off from all parts, even from the hinder portion of the mass still within the envelope, and it was not unfrequent to see a few spindles travelling from the margin of the body-mass to the wall. Further, it used not to be unfrequent to see in a well-stretched-out example that the granules remaining behind embedded in the mass, still in the head-quarters, showed more or less of a reticulated arrangement in rows, as if due to the presence of some of the filiform tracks permeating the interior of the unissued mass (Pl. VI). Still my impression would be that these remarkable linear tracks are comparable rather to pseudopodia, that is, that they are sarcode prolongations evolved *pro tempore,* and that there does not pre-exist a store of them, as it were, coiled up inside waiting the occasion; on "squeezing" one of these no trace of them is seen in the mass. Unlike the axis of the pseudopodia of Actinosphærium, I have not seen that they penetrate downwards into the portion of the mass whence they emanate, and hence one of the most singular puzzles is that the little globular body about to travel, which without doubt is distinctly *in* the general mass, when it passes to the base of the filamentary track, ascends it, becomes fusiform, and now it appears *on* it.

I have repeatedly tried in a variety of ways, by reagents, &c., to make out any structure of the nature of a *nucleus* in this organism, but in this I have failed. I could neither find a nucleus (as in Amœba, Pamphagus, Plagiophrys, Diaphoropodon, &c.) imbedded in the general mass, nor in the spindles themselves. The general mass is made up of the structures alluded to, and the spindles appear only as bluish plastic and quite homogeneous bodies, both as described.

Foreign incepted bodies, generally, if not always, algæ, were not infrequent. Sometimes one can see through even a densely filled and thickly enveloped and hermetically closed-in example the "digested" and defunct remains of perhaps a Cosmarium or Euastrum, &c., or an Oocystis or some such organism. The large example figured (Pl. VI) shows a brown and dead *Cosmarium cucurbita,* in another place an *Oocystis Naegelii,* equally brown and dead (but the characteristic arrangement of the endochrome not wholly lost), whilst next the extremity has been incepted an as yet scarcely altered example of a new and minute Spirotænia.[1] Around

[1] *Spirotænia gracillima* (n. s. mihi), very minute, linear, extremely slender, very slightly tapering, apices blunt, spiral turns very numerous; a

this has been consolidated the sarcode mass, which all the time gives off its filamentary tracks and spindles, the Spirotænia embedded in its midst.

Several times I have kept such glorious examples as that figured in a growing slide; after some hours the ramifications were drawn in, and there remained nothing but a "shapeless" mass sticking partially out of the torn opening of the envelope, or all had wholly disappeared. I never succeeded in directly tracing it, but there can be no doubt such can wholly retract and again secrete a wall, and completely shut itself up. Indeed it appears probable that an isolated or detached portion of the mass left apart also can so encyst itself—one might almost say indeed that this organism appears to have an *abhorrence* to remain long *without* a cyst; nay, even though seemingly the sarcode portion may not have emerged and offered the grand arborescent condition at all, still the contained mass will keep secreting a new coat, and adding yet another lamina to its perhaps already many stratified and much thickened envelope. And so, seemingly, after several egresses, retractions, recoatings, or subdivisions inwardly, and fresh recoatings, are brought about the numerous and manifold, often *outré*, shapes, in the encysted and dormant state assumed by this organism.

Anxious to find anything to indicate a reproductive process, I have delayed to bring forward even this so crude an account of this form; but in that hope I have failed. The only thing pointing thereto is a subdivision of the contents sometimes noticed into a considerable number of generally equal parts, sometimes a variation in size is noticeable (Pl. VII, fig. 3). These are globular in figure and seem at first to be without any wall. Such kept for a time on a slide by and by collapse shapeless; if they had a wall they would not do so. But, true to the idiosyncrasy of this organism, in a normal state, each of the balls is not long without forming a special wall (as in the figure), and a number of globular, smooth, simple-walled, secondary individuals are produced in the cavity of the large multilaminated primary one. One sees before one *something* like an *oogonium* of a Saprolegnian, but there does not appear *any* analogy between them.

Such is an attempt to convey an idea of this organism, which may perhaps stand for the present as *Chlamydomyxa labyrinthuloides*, as it presented itself in the natural condition, especially the first and second seasons of my making its

remarkable form from its extreme slenderness. Breadth $\frac{1}{9000}$ to $\frac{1}{10000}$", about 20 times longer than broad.

acquaintance. A word or two is requisite as regards the application of reagents.

I was surprised on applying iodine and sulphuric acid to find that this curious multilaminated coat, so conspicuous a portion of the make-up of this organism, gave a brilliant indigo *blue colour*, accompanied by a great swelling up of the constituent laminæ, the outer of which took somewhat of a violet colour (Pl. VII, fig. 6). In other words, this coat gave in a marked manner the cellulose reaction. At same time the inner basic substance acquired a pale homogeneous, somewhat verdigris green hue, and the granules, a brassy or yellowish colour, and shiny appearance, and became simultaneously of quite spherical figure, and rather small and regular size, each with a dark contour.

Boiled in caustic potash, a great swelling up and separation of the outer laminæ of the coat took place; and to some extent, the same in cold potash; the basic substance assumed a yellowish, sometimes faintly greenish, hue, and the granules became perfectly globular, more varied in size than under the iodine and sulphuric acid, but quite oily and shiny in appearance, and of a greenish-yellow colour (Pl. VII, fig. 5).

In Beale's carmine solution no very marked change ensued, and, as before mentioned, no body evinced itself anywhere as a nucleus, nor did any portion take indeed any extra dye.

Alcohol deprived the red granules of their colour, and changed the whole contents to a somewhat greenish yellow.

Such is the curious organism as it presented itself the first and second season of my meeting with it. Since then, much to my vexation, I have failed to encounter, except very rarely, examples displaying the active condition described; but it always now presents itself closely wrapped up in its coat, and densely filled with a preponderance of *red* granules. In that condition it is prone to occur, in considerable quantities, on the submerged surface of aquatic plants in the pools which it affects. The very first examples I met with were free at the bottom of the pool; and I therefore tried to examine this, to me, new phase more closely.

The first plant on which I noticed this was Sphagnum, but I soon found that this was only because other aquatics were more scarce in the pool; for the submerged leaves of sedges, of Eriophorum, &c., and more lately still, I noticed, in Connemara, that *Eriocaulon septangulare* also suited this organism as a host.

On examining a piece of Sphagnum, or other plant bearing this production, it may be often seen that the individuals are attached, sometimes in crowds, sometimes singly, by one of the before-mentioned neck-like prolongations, forming, as it were, a broad isthmus or neck, joining the great globose or lobed portion to the plant, but at other times they seem to lie upon the plant without any evident union with it. They are of variable size and, as mentioned, of most variable shape.

But on closely scrutinising some of the Sphagnum-leaves (ultimately other leaves), I was still more surprised to find very *small* examples, with a simple wall, or perhaps with a wall of two laminæ, unmistakeably *inside* the large hyaline cells with annular and spiral fibre (Pl. VII, fig. 2). These little examples were in every respect (except size and number of laminæ of the coat) like the external larger ones; very small ones were of an ellipsoidal or subglobular figure, but larger ones, not uncommonly, showed an elongate torulose figure, simply due to the example, now enlarging so as to fill the cell, and becoming at intervals cinctured about, and by reason of its expansive growth, constricted by the recurring annular fibres of the sphagnum cell (fig. 2, middle and left). Other cases could be found where such little examples protruded, hernia-like, on the surface of the leaf. Thereupon the "sarcode" with the granular colouring contents seems to pass up into the protrusion; then, true to its propensity, to form a fresh coat, leaving behind the original one, and thus seemingly explaining how these bodies come to cover the leaf here and there, *attached thereto* (Fig. 2, to right). No clue whatever have I been able to obtain as to how these bodies originally get into the cavity of the leaf-cell, or how their "germs" can enter. No doubt, in Sphagnum, one could suppose small germs could enter through the pre-existent openings or foramina in the wall of the hyaline cells, and through the same openings the hernia-like protrusions could make an exit without any material injury to the Sphagnum, for it is true that, for a length of time, it can thus harbour this organism without its seeming to suffer. But though this is so, it is no less true that when this organism at last grows to excess, the Sphagnum succumbs, gets eventually broken up, the tissue of the "leaves" disappearing and nothing left but the "stem" and "branches" covered by this growth, and such portions seem to be at last utterly "killed."

But if it were supposed that in Sphagnum "germs" could make their way through the openings in the leaves, the same supposition would not hold good, as regards other plants, without such normal openings in the cells. Of such none offers a more curious example than the cells (of the roots) of

Eriocaulon. Of this curious plant small specimens are sometimes found floating on the surface of the water, and though defunct, their tissues seem not in any way injured or disturbed. *Inside the cells* of this plant small examples of this organism are sometimes to be found, to all appearance, hermetically closed in, and without any evident mode of ingress. But it would be unreasonable to suppose that it could be self-generated in the plants it inhabits. Other endoparasites, penetrating from without, as is well known, exist. In other leaves, where it can be seen occupying intercellular spaces, the marvel becomes, of course, very much diminished. It may be found (in Connemara) covering *Batrachospermum vagum*, and lodged in numbers between the cortical layer of filaments depending from the nodes, which become dislocated, and portions of the plant distorted, but such is not very surprising. But as to how this production gets *into* cells of several diverse plants inhabiting the same pool is a mystery to which I regret I have no clue.

In certain leaves of Sphagnum in which unmistakeable young individuals occur, and again in others in which such did not reveal themselves (not always, however, absolutely critically examined), certain growths can be seen, generally somewhat to one side of the hyaline cell, and sometimes pressing in upon, and distorting, the intermediate chlorophyll-bearing cells. This forms an elliptic, greenish, coarsely granular mass, surrounded by an irregular, colourless, hyaline, indistinctly bounded, roughly striate covering (Pl. VII, fig. 1). Sometimes two of these may occur in one cell, and if at the same level, or side by side, they together may press more upon the adjacent cells, and cause somewhat more marked distortion. I have not been able to satisfy myself that these have a genetic relationship to the subject of this paper, but I am inclined to think they may have.

Although, then, no "reproductive" condition or development of "germs" of any kind has ever rewarded my repeated collection and examination of this organism, at different periods of the year, so far as I am aware, nothing essentially agreeing with its general and special characteristics has before been described. But one cannot look up Cienkowski's figures of his Labyrinthula-forms, or read his account of them (*loc. cit.*), without being struck with the strong *resemblance*, if, indeed, it may turn out to be no more.

It becomes necessary, then, to refer to the description given by Cienkowski (*loc. cit.*), of the two forms for which he founded the genus Labyrinthula, and the only one of the new group "Labyrinthuleæ."

Labyrinthula vitellina, Cienk., forms little brick-red, or orange-coloured patches, about the size of a pin's head, upon seaweeds covering the piles in Odessa harbour. Placed under the microscope, and allowed to repose for some hours (say twenty-four), three principal constituents catch the eye of the observer: the "central mass," the "spindles," and the "filamentary tracks" ("Fadenbahn," Cienk.). The "central mass" consists of globules (0·012 mm. in diam.), with a very delicate contour, and of a brick-red or yelk-yellow colour, which in the aggregate are held together by a delicate, finely granular, basic substance, often presenting, externally, a thin colourless margin. Passing off therefrom in various directions are seen numerous slender, mostly very thin, anastomosing strings, the "filamentary tracks." Towards the periphery of the mass the little orange-coloured globules acquire a more elliptic figure, and they can be watched passing up, one by one, upon the tracks, where they assume a fusiform figure, and gradually, but very slowly, glide onwards. In the course of several hours the greater part of these little bodies have ascended the tracks, and slowly pursued their way to the margin of the drop of water. It is therefore clear the little globules at first seen, and the "spindles" afterwards found travelling on the slender tracks, are identical. Their contour is very delicate, they never become fused, though do not seem to possess any evident membrane. The middle of each is occupied by "*a nucleus*, appearing like a clear vacuole, enclosing a strongly refractive nucleolus;" they increase in number by self-division, and are hence to be regarded as true "cells." Treated with tincture of iodine, a sharply circumscribed contour makes its appearance on their surface, becoming brown, and standing off, more or less, from the contents. Alcohol dissolves the pigment, leaving the globules deprived of colour; the spindles so treated do not become blue by iodine, which at once takes place when tincture of iodine is added to fresh material; allowed to operate longer, the whole spindle becomes dark brown. The behaviour of the pigment under sulphuric acid shows it belongs to the category of colouring substances, forming the red specks ("eye dots") of Euglenæ, Rotatoria, the orange-yellow contents of Uredines. They are very contractile, altering their figure on contact as they glide along. Their main direction is centrifugal, towards the margin of the drop of water in which they are under observation, but they do not always take the shortest course; they appear also capable of gliding over one another; some of them thus delayed *en route* may preserve their original globular figure; but having passed the obstacle, upon a fresh start the fusiform figure is reassumed. Sometimes, says the author, a backward motion may take place, "though indeed the final exit from the water appears to be the purpose of this curious wandering." As to the cause of the movement, the author knows of no fact capable of leading to an explanation, being of opinion, however, that, "owing to the rigidity of the track, the cause is to be sought in the spindles, though the latter, away from the track, have not the power to move."

Touching the "tracks" themselves, the author seems to regard them as not differing except in tenuity from the general hyaline basic substance. He was able, by the application of acetic acid, to perceive that the previously seemingly uniform substance now showed a very fine fibrous structure, and pressure on the covering-glass enabled him to detach the strings from the central body. When, however, the whole fabric becomes fully evolved under the microscope (that is, the whole "tree" or "labyrinth" developed), it seems to possess no contractility, evinces no movement on the surface or in the interior, no projection or retraction of processes or rays comparable to the pseudopodia of the Rhizopoda, the whole is now a rigid, motionless structure (except, of course, the wandering spindles). The author would leave the question an open one as to "whether the tracks represent a system of communicating tubes, or solid interwoven threads."

The principal difficulty in his arriving at a conclusion is due to the extreme minuteness of the threads, which scarcely allows of the mutual relation of these to the spindles being observed. The author could not satisfy himself as to whether the spindles executed their movement *in* the threads or *between* them; as he regards the passage of a spindle, from the main filament to a branch, as being compatible with either interpretation. Also, he says the fact that, upon the application of iodine, the contour then seems as standing off from the spindles, directly continued above and below into the filaments, may be used in favour of either view: this contour, with its dependent threads, may be interpreted as the expression of a "tube in which the spindle moves, or as that of two threads in contact longitudinally." The author himself leans to the latter view.

Notwithstanding the seeming *fibrous* nature of the mass under certain circumstances, and occasional tuft-like pencils of short linear prolongations making themselves sometimes apparent, Cienkowski thinks there is not thereby afforded a reply to the query whence properly the material to form the tracks proceeds; is it the basic substance of the central body which breaks up into the interwoven threads, or is it the spindles themselves which directly build up the whole framework? He replies, that naked clusters of spindles, or even isolated spindles, without combining basic substance, *are* so capable, and that the latter takes no share in forming the aggregate framework, but whether only the apices of the spindles or their whole surfaces contribute to emit it he expresses himself as uncertain.

The other species described by Cienkowski, *L. macrocystis* agrees in all essential points with the foregoing. Its spindles are larger (0·018 to 0·025 mm.), of firmer consistence, the nucleus more sharply marked, the contents more granular, than in *L. vitellina*, and they are colourless, or of a pale yellow tint. Neither iodine nor sulphuric acid produces a blue colour. As in the previous species the spindles increase by self-division. This form occurs on the piles at a higher elevation than the preceding, therefore not submerged except by the surf. Hence it is regarded by the author as explicable why, in this form, the spindles are more prone to pass into a "cyst" or "spore." Preparatory thereto, the cells enlarge, become more richly granulate, darker in colour, the spindles become oval, and each acquires, besides its own membranous covering, a thick-walled smooth envelope; the basic substance possesses a glassy, rather firm, consistence, retaining the outline of such "cysts" as are ejected by force; on the surface of the cluster there is formed a granular layer of darker colour than in the interior. After a pause the contents of the encysted "spindles" become divided into four portions, the coat disappears and they remain free, as motionless globules. This taking place, in many instances produce numerous closely lying little groups, the little bodies soon assuming the fusiform figure, already accompanied by the "tracks," indispensable for their movements.

Such is a very much epitomised abstract of the author's memoir, and he sums up the conception of the Labyrinthuleæ as follows:—

1. Clusters of nucleus-containing cells, increasing by division, possess a certain degree of contractility, at times becoming enclosed in a basic substance.

2. These cells give off a fibrous substance, which becomes formed into a rigid structure, forming reticulations and arborescent ramifications.

3. The cells leave the clusters, gliding away, by manifold circuitous routes, to the periphery of the drop, but the Laby-

rinthula-cells can carry on their wandering only when supported by these filamentary tracks.

4. The wandering cells combine anew in clusters and pass over into an encysted state, each cell acquiring a firm envelope, all held together by the common basic substance.

5. From each cyst, after a rest of some time, four globules are formed which extremely probably become changed into young Labyrinthula-cells.

Thus, notwithstanding the great resemblance, there are some points of difference of such seeming great importance as possibly to forbid the present organism being subordinated to the Labyrinthuleæ. In the first place the "spindles" are not nucleated, in the next they do not (seemingly) ever become themselves encysted, but the aggregate group, matrix, colouring granules and all, become repeatedly so, and that in a cellulose coat; in the third place, Cienkowski's Labyrinthuleæ do not possess other colouring granules besides the spindles—in the present form there are green and red alternating; and, in the fourth place, the former do not show contractile vacuoles, a conspicuous feature in the latter, under certain conditions; nor did Cienkowski see any organisms incepted into their mass; and, lastly, Cienkowski's forms did not evince any parasitic nature.

The first objection seems to be the most important. Might it, however, possibly be met by assuming the spindles in the present form to be, as it were, *all nucleus?* Cienkowski offers no conjecture as to any seeming or probable purpose of the strange wandering of the spindles, save "to reach the periphery of the drop, or to get out of the water;" still he says they can recede. The object would naturally seem to be to transport the spindles to a distance from the primary mass, and to distribute them around in order to lay the foundation of a number of new centres. Quite in a similar manner the spindles in the present form tend to pass away from the original centre, and masses, accompanied indeed by a greater or less quantity of the basic matrix, are sometimes left apart to form new centres. I cannot say, indeed, whether or not a single spindle would have the power to lay the foundation of a new and independent centre of growth, like to that which it left behind, but it might not be unreasonable to suppose that in this way the slender filamentary tracks, reaching far and wide, may be simply the medium of transporting to, and depositing these spindles within, the tissues of the adjacent submerged plants, in the way which we have seen it to occur, there to develope.

As to the second objection, that the individual spindles do not become specially encysted, but the whole of them, along with the other granular structures in common, might be only of secondary importance; more cogent, indeed, is it perhaps that they have not been seen to *divide*, but after all it is a probable way of their increase.

The remaining objections seem rather to relate to questions of habit, or might be considered in themselves as touching upon points rather of mere "specific" signification than of higher import. Cienkowski's forms might yet prove to be parasitic; they at least grow upon and surround the adjacent algæ. Cienkowski's forms took some twenty-four hours on a "slide" to grow up into a "tree" like that shown in his figures; the present form has often presented a spectacle like that shown in Pl. VI in less than as many minutes.

If the spindles in my form were *nucleated, i.e.* if they represented "cells," not merely plastic, homogeneous, little masses, the present organism would seem to be necessarily relegated to the Labyrinthuleæ, apart from the other points of difference.

The "filamentary tracks" in Cienkowski's forms and in the present organism seem wonderfully to resemble each other, so much so that, whatever be their mode of evolution, it is probable this is alike in all. As has been seen, Cienkowski ascribes the origin of the filamentary tracks to the spindles themselves, in other words, a spindle must exist before a track; the former must first exude or give off the filamentary substance ("faserige Substanz"), then pass *along* (?), or *in* (?), or *between* (?), the threads so produced, but *which* the author leaves an open question. But this does not, seemingly, quite coincide with his description of the basic substance, a "zarte, feinkörnige Rinden-Substanz," often forming at the periphery a thin enveloping layer, where again its substance is spoken of as either "ganz hyalin, einförmig" or as showing a "sehr feine faserige Structur," and where it has the power to give off branches, of a glassy appearance, gradually tapering off; these may be of a uniform appearance, or show a very fine fibrous (faserig) structure, and at the margin sometimes running off into very thin, scarcely perceptible rays, sometimes fringe-like, at others tufted and all this seemingly without the direct presence of any of the spindles. These fine linear threads seem to be nothing more nor less than the "tracks," as yet very short. In one form the tracks, if I mistake not, are given off independently of the spindles, but they are no sooner there than spindles are seen thereon (or therein?). As I have mentioned as regards my form, and as will be seen in the figure, a more or less reticulated arrangement of the "spindles" (not *now* of fusiform figure) may be seen in the interior of the central mass, suggesting their arrangement along "tracks" enveloped by the general substance, but this is only conjectural (Pl. VI). In *both* Cienkowski's and the present form the tracks give off branches and incorporate with others which they cross, admitting of the spindles taking very circuitous routes.

In Cienkowski's forms he mentions that the tracks (rigid as they seem at first) *by and by* take on "a mucous consistence, more or less enveloping the spindles," and they form "knot-like expansions, in which vacuoles occur," but notwithstanding these facts, the author regards the tracks in such condition as only "most deceptively presenting the appearance of a protoplasm-plate." In our form the tracks seem to be given off from the central mass (pseudopodium-fashion), and can be wholly or partially retracted.

Cienkowski denies to the spindles any power of motion *except in connection with the tracks*, but in both of his and in the present form these have the power spontaneously to leave the general crowd inside the central mass, at first without apparent contact with a track, then (*proprio motu*) to *mount* the one along which it is to make its journey.

But, further, in connection with a fungal the identity of which was unknown to the author himself, Cienkowski had previously drawn attention to a filamentary form of plasmodium, with "spindles" moving along the threads.[1] This ("fungal") he describes thus (curtailed):—"Upon culture of these for some time upon a slide I found the entire field covered over by a branched network of threads, which here and there showed fusiform thickenings. Upon following the course of these threads for certain distances, large differently shaped colourless protoplasma-masses were encountered, from which the whole structure drew its material as from a reservoir—so to say, budded out from it. Upon attentive examination of the plasma-aggregates, it rendered itself apparent that, at any place thereof, a projection or prominence first makes its appearance. This prominence becomes constricted at its base, assumes a fusiform figure, then, removed from the principal mass, drawing a thread with it. In the same way sprouts out from the protoplasm a new spindle, which likewise thins off at its base into a thread and follows the one first formed. Whilst thus continuously new spindles and threads proceed from the main reservoir, and become carried along the 'track' ('Fadenbahn'), the whole thread creeps forwards,

[1] Cienkowski; "Das Plasmodium," in Pringsheim's 'Jahrbücher für wiss. Bot.' Bd. iii, p. 408.

the end spindle directed foremost. The filaments proceeding from the reservoir are to be identified with the basic substance of the plasmodium, the spindles and strings with the granular substance. The movement of the thread is extremely slow, scarcely directly perceptible, that of the spindle much more noticeable.

"*En route* the spindles may not be equally mutually remote; here and there one becomes accelerated, and lays itself longitudinally on the one preceding it; this is followed by another, and so on. In this way originates a cluster of spindles which fuse together in a string, continuing its way; the thread, however, keeps its own position and extension. We are thus here compelled to distinguish between the less motile basic substance and a second gliding one. Another interpretation that the spindles are but enlargements of the threads, which become moved up and down, is inadmissible, because the spindles, as we have seen, considerably alter their figure *en route*, coalesce, become divided, and proceed from the main reservoir."

The author at the conclusion of his memoir on the Labyrinthuleæ[1] again refers to this curious "Fadenplasmodium" appertaining to the unknown fungal (taken by him, he now mentions, from the earth of some flower-pots), and he regrets that he was never able to refind it for further examination with the fresh light and new experience derived from the study of the two marine forms constituting his new group named Labyrinthuleæ. At that time, as is seen, he regarded "the central balls as protoplasmic bodies, from which each spindle upon beginning its wandering was produced by constriction. That the spindles pre-exist in the central clusters as such, or in the form of globules, was then a fact unknown to him, whether it were that this differentiation in the filamentary plasmodium (Fadenplasmodium) was not really existent at all, or that the delicacy of the object and the difficulty of observation concealed from him the true state of facts. The filamentary plasmodium observed under a covering glass always perished, for at that time he had made no use of the 'moist chamber.'"

There is thus pretty evidently a considerable resemblance in this organism, *whatever it be*, to that herein described.

The author alluded in his previous memoir on the Plasmodium to this "enigmatical" production in order to compare it with certain very similar though not seemingly at all identical conditions of the plasma of certain Mycetozoa.[2]

[1] Loc. cit., p. 308. [2] Ibid., p. 405.

Referring to certain filamentary forms assumed thereby, he draws attention to the "formation of lenticular enlargements of the basic substance of the threads. The number and size of these of course depends upon the persistence of the interruptions of the current, as also upon the quantity of the substance flowing onwards after each interval of pause. These isolated masses of the granular substance can glide along the thread up and down, approach, coalesce into a larger expansion, or become removed from one another; the basic mass of the thread remains also here motionless."

Now, I am much inclined to think that a comparison of the phenomena as here described by Cienkowski for the Fadenplasmodium in Mycetozoa, with those evinced by the organism brought forward by me in this communication, still less a determination of these as but the expressions of similar structures would not be tenable. The appearances and characteristics evinced by my form seem more to admit of comparison with the fungal (from the flower-pot) referred to by Cienkowski, but there appear, so far as can be judged, general points of difference—of course no one could for a moment regard them as identical. If we judge aright from Cienkowski's figure,[1] the "spindles" in his unknown organism (from the flower-pot) do not seem of differentiated character from the tracks; they *seem* to be composed of the basic substance, and to contain the same extremely minute granules, notwithstanding that they have an independence of movement. Unlike the marine Labyrinthuleæ, they do not seem to be nucleated, and in that respect would agree with those of my organism. But in the latter the "spindles" are undoubtedly pre-existent in the central mass, and are of quite different colour, consistence, and character from the basic substance containing them, or the "tracks" on which they travel.

We have thus to do with an organism singular in its details and highly puzzling as to its real nature—one which offers but few resemblances to recognised and described objects. Its outward "facies" and its most striking resemblances doubtless suggest affinity to the Labyrinthuleæ, especially *L. vitellina*, Cienk., but this *may* be a mere resemblance, nothing more, if we were acquainted with its development. It, like the marine forms, has a resemblance to Cienkowski's as yet, even to him, enigmatical fungal (from the flower-pot); it has a less striking resemblance to conditions of Mycetozoa, as pointed out also by Cienkowski. In the absence of a "nucleus" it agrees with Monera

[1] Loc. cit., T. XIX, f. 5 and 6.

(Häckel). But, whilst it as yet shows no "fructification," no reproductive process, in any more strict sense of the word, a decision as to its real nature must remain in abeyance. Meantime, in itself and its specialities, it is an existence quite distinct from any other hitherto described, at least so far as I have noticed.

I am myself very strongly inclined to hold by the view that Sarcodic existences (at least those of the fresh waters), that is, "Rhizopoda," in a broad sense, embracing various types, simple as they are, are, in fact, very fixed and permanent organisms. Bound up with certain "forms" seem to be their own inherent specialities of structure and of texture, their peculiarities of temperament (if one might be allowed to use the word in relation to so lowly objects), their idiosyncrasies of behaviour, of manner, of habit, their peculiarities of colour, or its changes, their greater, or less, predilection for crude "food," or seeming total abstinence; and although the present organism cannot be looked upon as belonging to Rhizopoda, it is, at least, not less strongly marked than any of the not very numerous but yet multifarious sarcodic existences which the fresh waters, more or less abundantly or scantily, offer to notice. But still any generic or specific "characters" that could be ascribed to it would seemingly be of but a temporary or artificial nature, pending its further history. Since I first met with it, it has pertinaciously refused to present any additional particulars as to its development. The nearest site at which I know it to occur is some sixty miles from Dublin, but I am inclined to suppose it will not turn out to be *very* uncommon, and at other seasons, or other localities, to other observers, it may unfold more of its history and further data, to throw a light on its true nature.

Ad interim, it may perhaps be well to epitomise its description, without attempting to refer it to any special class or order for the present, under the name of

Chlamydomyxa labyrinthuloides, n. g. et sp.

Generic characters:—

Body substance enclosed in a multilaminated cellulose envelope, whence, through an apparently lacerated aperture, the non-nucleated granule-bearing protoplasmic contents now and again emerge, irregularly giving off at the same time in an arborescent manner gradually tapering ramifications, and emitting numerous extremely slender hyaline ramifying threads ("filamentary tracks"), occasionally coalescing and forming a more or less complex "labyrinth," along which proceed from the central mass (as from a reservoir) numerous little therein pre-existent, non-nucleated globular, but plastic, bodies, which during progression assume a fusiform figure ("spindles").

Specific characters:—

Very variable in dimensions, in an early stage endoparasitic, that is, living within the tissues of aquatic plants; general mass, with or without subdivision, becoming periodically repeatedly encysted; enveloping coat hyaline, glossy, of a pale, yellowish colour, when viewed at margin (or through its greatest thickness); remaining thus long dormant, and in that condition the "spindles" globular; pigment-granules yellowish-green or bright red, rounded, or irregularly shaped, very dense; now and again putting on the energetic condition, and forming a highly ramified, arborescent structure, the central mass then presenting numerous rounded pulsating vacuoles; the "filamentary tracks" extremely slender, quite hyaline, the "spindles" bluish in colour, homogeneous in appearance, plastic, their progression slow, gradual, gliding; when in motion, about $\frac{1}{3000}$ to $\frac{1}{4000}$ of an inch in length and about half so broad.

On the Thread Blight of Tea.

By the Rev. M. J. Berkeley, M.A., F.L.S.

The tea plant, like every other subject of cultivation, is exposed to its own peculiar enemies within the animal and vegetable kingdom. The leaves are often mottled with black spots, which were first supposed to be due to a minute fungus, but which have been ascertained to be caused by a little bug belonging to the division *Capsidæ.*

There is, however, another affection, which seems to be equally destructive, which is known under the name of thread blight, which is undoubtedly due to a fungus which, under the form of white, creeping, mycelioid threads, runs over every part of the plant, even extending to other shrubs in the neighbourhood. The specimens before us of an *Andrachne trifoliata* as well as the tea plant, and other shrubs have been attacked, as, for example, seedling chestnuts. The fungus itself is white, consisting of creeping, more or less flattened bodies, solid within but externally clothed with flexuous threads in which, as far as we have ascertained, there are no joints (fig. 1). There was not the slightest trace of fructification, so that it is impossible to state to what genus they belong.

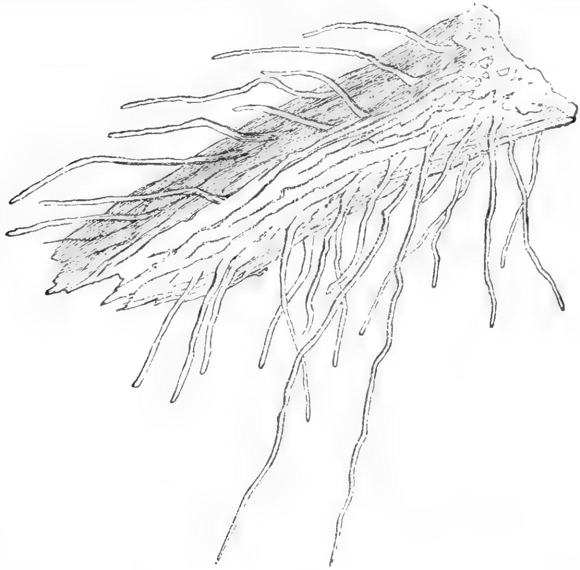


FIG. 1, the tip of one of the creeping bodies magnified.

It is not, however, uncommon in tropical countries for fungi to be developed on living plants, either on the stems or leaves,

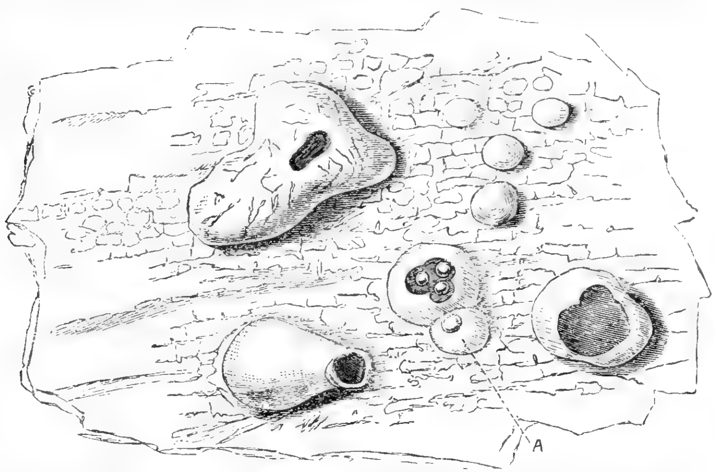


FIG. 2, represents a portion of leaf of *Andrachne trifoliata* with the blister-like bodies, and a minute *Strigula* (A), magnified.

where there is considerable moisture accompanied by heat. In such situations *Dictyonema sericeum* is not infrequent, and is generally felted with a green alga; and *D. spongiosum*, a far finer species with the same cracked hymenium, occurs in Cuba. *Polyporus fruticum* grows in the same island on living shrubs, often clasping the twigs, while *Rhizina spongiosa* grows vertically in similar situations gorged with water; besides which we have *Cora pavonia*, *Thelephora pedicellata*, *Hypolyssus Montagnei*, in similar situations, and, what is perhaps more nearly to the purpose, *Rhizomorpha corynephora*.

There were one or two parasites on the leaves belonging to the epiphyllous lichens of the genus *Strigula*, but scarcely in a sufficiently perfect state to give their specific names. One of these (fig. 2 A) had perfect minute black perithecia containing clavate asci with linear curved sporidia ·0001 inch long (fig. 3). Besides these were little shield-like bodies

FIG. 3, asci and sporidia from (A), magnified.

consisting of cells radiating from a central aperture containing oblong, staff-shaped, triseptate spores, hollowed out at the sides, ·001 inch long, on slender pedicels, and inclosing a pale green endochrome (fig. 4). Whether these are a

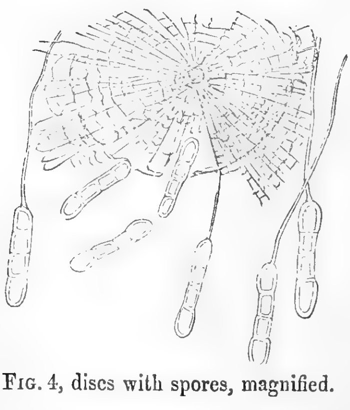


FIG. 4, discs with spores, magnified.

state of some *Strigula* or of some minute ascomycetous fungus it is impossible, perhaps, to say with certainty. It is, however, a very pretty object under the microscope.

There were besides on the leaves irregular bullate bodies (fig. 2) resembling *Cystopus*, but without any trace of fructification. It is not, however, supposed that these parasites are really in the first instance injurious, as they are produced only on the leaves when they are so far advanced that they are useless for any economic purpose, though it is possible that if they occurred to any great extent they might have some influence on the product of the succeeding year, and the same is possibly the case with the thread blight.

Observations *on* Spontaneous Movement *of* Nucleoli. By P. Kidd.

During an examination of the ciliated epithelial cells from a frog's mouth Dr. Klein drew my attention to certain cells with special characters to be referred to presently, the nucleoli of which exhibited a crenated appearance; this aroused the suspicion of this being due to amœboid movement. They were therefore subjected to a continuous and careful observation, and it was found that this was actually the case, viz., that these nucleoli perform spontaneous movement. In an ordinary saline solution preparation in which these movements were observed they were, although distinct, yet not very marked, and it was therefore desirable to repeat the experiment under more favorable conditions. A portion of epithelium from the same frog's mouth was prepared between two thin cover-glasses, in a drop of "humor aqueus" and a thin layer of oil was then painted round the edges of the cover-glasses. The specimen was then placed on a Stricker's warm-stage, and examined under a No. 10 immersion of Hartnack. The temperature of the warm stage was about 39° C. Several cells were again found similar to those before noticed, viz., cells differing from the other epithelial cells in having no cilia, in their distinct outline and large size, and in the pale and uniformly granular nature of their protoplasm. They possessed a large ovoid vesicular nucleus like the other epithelial cells present, and were provided with a large nucleolus, sometimes with two nucleoli. The larger nucleoli measured 0·002 mm., the smaller 0·0015 mm. in diameter. As far as morphological characters go these cells were not lymphoid corpuscles, for they were very large, much like columnar epithelial cells, at the same time somewhat irregular in their outline. It should be mentioned that as the frog was suffering from inflammation of the mucous membrane of the mouth, these special cells, from their large size, irregular shape, and the absence of cilia were probably young epithelial cells. On observing one of these cells after a short time a process was developed from its nucleolus, which very soon after was seen to undergo a change not only in length but also in direction. In two or three cases the processes given off from a nucleolus possessed a knob-like projection at their free end, which seemed to vary in distinctness in the course of the observation. After a few days another examination of the epithelial cells from the mouth of the same frog was made under similar conditions, that is to say, the cells were examined between two cover-glasses in a drop of "humor aqueus," on a Stricker's warm stage. Again, amœboid movements were observed in the nucleoli of these special cells, two or more processes were observed to spring from several nucleoli. In some cases these processes were provided with a small lateral branch, and in one instance such a branch disappeared and a corresponding branch appeared at another point.

From Waldeyer's Report in the 'Jahresbericht über die Leistungen und Fortschritte in der Anatomie und Physiologie' for 1873, I find that Auerbach in his treatise on nuclei attributes amœboid movement to the nucleoli from certain irregularities in their shape; he has not, however, observed these movements. Metschnikoff, on the other hand, has observed movement in the nucleoli of salivary glands of larva of ants. Balbiani and v. La Valette St. George observed the same in the germinal spot (*i. e.*, nucleolus) of the ovum of the spider and dragon-fly. Quite recently Dr. Alexander Brandt described amœboid movements observed in the nucleoli of the ova of Blatta Orientalis (Max Schultze's Archiv, vol. 10, part iv).

The STRUCTURE *of the* PACINIAN CORPUSCLES CONSIDERED *with* REFERENCE *to the* HOMOLOGIES *of the* SEVERAL PARTS COMPOSING THEM.

By EDWARD SCHÄFER, Assistant-Professor of Physiology in University College, London. (With Plates VIII and IX).

STUDIED generally, a Pacinian corpuscle may be looked upon as consisting of three parts—the central fibre, the core, and the capsular enclosure. I propose in the first place to note down the result of observations upon the structural appearances presented by each of these parts, as ordinarily met with, without entering into the consideration of the variations which present themselves more than may seem necessary for the elucidation of the structure; and then to discuss briefly the homologies which the component parts of the Pacinian corpuscle severally bear to the parts which compose the entering nerve, at the same time indicating the manner in which the structures of the one appear to become continued into those of the other.

The observations were in all cases made upon the Pacinian corpuscles from the cat's mesentery; these having been selected on account of the facility with which they are obtainable in the fresh condition, combined with the fact that, according to the unanimous testimony of observers, their structure differs in no essential particular from that of the corpuscles met with on the nerves of various parts of the human body.

The Central Fibre.

As first shown by Grandry, this presents a distinct appearance of fibrillation, the fibrils, as a rule, crossing one another very obliquely (see Plate VIII, fig. 2, *e f*); thus rendering it difficult or impossible to trace each separate fibril throughout its whole length. The central fibre is uniform in size except towards its extremity, where most commonly it becomes enlarged; but sometimes there is no distinct swelling, the fibre being merely marked at its sides with minute denticulations or projections, from which, in preparations stained with chloride of gold, fine fibrils occasionally appear to proceed outwards. (In one instance the central fibre terminated abruptly after traversing only two thirds of the length of the core, by a rounded extremity, uniform in diameter with the rest of the fibre.) The terminal enlargement, when present, varies much both in size and shape, in some cases having a simple rounded outline, in others an irregular shape, with acuminate processes. Its substance either appears granular, or more homogeneous, and refracting the light strongly ; in the first case the fibrils composing the central fibre may often be seen to spread out into the substance of the enlargement; in the second this last is probably covered with a thin layer of white substance similar to that composing the medullary sheath of the nerves, and the arrangement of the fibrils is thus obscured. The terminal enlargement as well as the remainder of the central fibre becomes deeply stained by chloride of gold, much more deeply than the substance composing the surrounding core, but even in very successfully stained preparations I have hitherto failed to discover a fine network of nervous fibrils around the extremity, as described by A. Budge. If the terminal enlargement is of considerable size it may contain a clear, round nucleus, with nucleolus, generally obscured by the granular substance of the enlargement. A nucleus is not, however of frequent occurrence, as Jacubowitsch and Ciaccio have described.

It is not at all uncommon to find the central fibre accompanied for a short distance within the core by the white substance of the medullary sheath (B, fig. 3); this has been noticed by various observers, as well as the fact that the white substance may reappear here and there, especially at a bend in the core; I have besides in more than one instance noticed the medullated fibre passing quite through one Pacinian (generally a smaller one) to terminate in another, without loss, or even diminution in thickness, of its medullary sheath (A, fig. 3). Axel Key and Retzius also describe the fibre as occasionally retaining the medullary sheath as far as the terminal enlargement. Ordinarily there is no medullary or white substance surrounding the fibre in its course; this fact is readily determined by the action of osmic acid, which speedily blackens the fatty substances which mainly compose the medullary sheath of the nerves.

Sometimes, when the central fibre bifurcates, one of the branches may retain a medullary sheath and the other be continued as a pale fibre.

With regard to the presence or absence of a membranous structure corresponding to the primitive sheath (Schwann's sheath) of the nerves, it will be sufficient here to state that no indication of such a structure could be detected immediately investing the central fibre, either when viewed longitudinally or in transverse section, nor any nuclei in the immediate neighbourhood of the fibre which might belong to such a sheath.

In its behaviour to staining fluids the central fibre of the

Pacinian corpuscle precisely resembles the axis-cylinder of a nerve.

The Core.

The substance composing the core is commonly described as being alike throughout; but in many corpuscles, if not in all, an outer nucleated part, of variable extent, may be disguished from the almost homogeneous, non-nucleated substance which immediately surrounds the central fibre. On careful focussing, and under a high power of the microscope, the inner part presents an appearance of indistinct longitudinal striation, which in a transverse section appears irregularly concentric (see Plate VIII, fig. 2 A); the outer appears composed of protoplasmic cells, like connective-tissue corpuscles, each with a clear oval nucleus; next to the inner part are a few flattened nuclei seen in section as mere lines.

Osmic acid (as shown by Michelson), chloride of gold, hæmatoxylin, and most of the ordinary staining fluids, colour the whole core much as they colour protoplasm.

The Capsular Envelope.

The structure of this can only be properly elucidated by the study of sections and by teased preparations. Examined in the ordinary way, fresh, in an indifferent fluid, the core of the Pacinian corpuscle appears, as is well known, surrounded by and enclosed in a number of concentric membranous "capsules," which, since Hoyer showed that treatment with nitrate of silver brings to view epithelioid markings upon them, have since been commonly regarded as composed each of a single layer of flattened cells with a certain amount of connective-tissue fibres, both white and elastic, on one or both surfaces. The so-called capsules, also, appear separated from one another by a clear fluid, less in amount both close to the core and near the exterior of the corpuscle, so that at these parts the capsules appear closer together than in the intermediate region.

But a new[1] view of the structure has recently been brought forward by Axel Key and Retzius, according to whom the supposed simple capsules each consist of *two* layers of flattened cells, placed, as it were, back to back; and they draw attention to the fact, which had been previously pointed out by Ciaccio, that the intercapsular spaces are not merely filled with an albuminous fluid, but are, to a greater or less extent in different parts, pervaded by fibres both white and

[1] A somewhat similar view seems to have occurred to Henle and Kölliker, and to have been rejected by them.

elastic, which are more abundant in the immediate neighbourhood of the cells, forming, here, in fact, definite layers, but some of which pass obliquely across the interspaces and connect these layers. The observations here to be recorded as to the structure of the capsular envelope are for the most part confirmatory of those of Key and Retzius.

The fibres which lie between the so-called capsules may be seen even by the ordinary method of examination, but since their general direction is transverse to the long axis of the corpuscle they appear mostly as fine dots or granules in the fluid (fig. 2), being seen in optical section; by the employment of the fine adjustment, however, it may be determined that the dotted appearance seen is in reality due to the presence of fibres.

In thin sections of Pacinians which have been prepared with chloride of gold the layers of the capsular envelope, at least the outermost ones, are readily separable, as shown in Pl. IX, fig. 4, *a a'*. In such preparations the albuminous fluid between the so-called capsules is coagulated, and the membranes which bound it are thereby more firmly united, so that when an attempt is made to separate the layers the separation takes place at the line of the capsules, that is, between the two layers of cells of which each so-called capsule is composed. So that we are able to peel off from the capsular envelope layers or tunics which are covered on either surface by a stratum of epithelioid cells, the space between these strata being occupied by fibres and an albuminous fluid, or, in other words, the coats of the Pacinian corpuscle are in reality hollow, and composed of the following structures, viz. a layer of thin flattened cells bounding them externally; a space containing a clear fluid with a greater or less number of fine fibres, the latter being chiefly collected near the cells, but some extending obliquely across the interspace; and a layer of flattened cells bounding the space internally.

What have hitherto been called the capsules of the Pacinian corpuscle are not isolable without rupture of the fibres which stretch across the interspaces, and each capsule must therefore be regarded as belonging half to one tunic of the corpuscle and half to another. Sometimes, indeed, as has long been known, a cleft containing fluid may here and there be seen between the two halves, these being slightly separated from one another. It will therefore be better, in future, altogether to discard the term "capsules" and to speak only of the "coats" or "tunics" of the corpuscle, meaning thereby the hollow layers, bounded by flattened cells, above described; to apply the term capsules to these compound tunics, as Key and Retzius propose, would be productive of endless confusion, the term having been so long used in a different sense.

By far the readiest mode of demonstrating the fibrous structure of the coats of the Pacinian is to immerse the latter in dilute solution of chromic acid ($\frac{1}{6}$ per cent.) for some days, and then either to make thin sections of the corpuscle with a razor, or carefully to break it up with needles upon a glass slide. If the latter method be employed it will be found that the tunics of which the capsular envelope is composed very readily tear in a direction transverse to the axis of the corpuscle, and small shreds are obtainable which exhibit the general structure of the tunics and the arrangement of the fibres within them in the clearest possible manner. This is shown in surface view in fig. 6, Plate IX, and in profile in fig. 5; the details of the structure will be best understood by referring to the description of the Plates.

Continuity of the Structures composing the Entering Nerve with those of the Corpuscle.

The entering nerve of the Pacinian corpuscle consists usually of a single medullated fibre enclosed in a prolongation of the neurilemma of the nerve-trunk from which it springs.[1]

Enumerating the structures which compose the nerve-fibre and its special sheath from within out, there is, first, the axis-cylinder occupying the centre of the fibre; around this the medullary sheath or white substance of the nerve; immediately external to this a delicate layer of protoplasm with clear oval nuclei imbedded in it at definite intervals (the protoplasm is more abundant in the neighbourhood of the nuclei, and the layer is, moreover, much better marked in young nerves); this protoplasmic layer is enclosed by the

[1] By the term *neurilemma* has long been described and is commonly understood the special sheath, now ascertained to possess a laminated structure, which envelopes each funiculus or bundle of nerve-fibres, and a prolongation of which may often be traced accompanying even single fibres, as, for instance, in the case of those passing to the Pacinian corpuscles. Moreover, Ranvier, to whom we owe much of what is known concerning the structure of the funicular sheath, retains the use of the term. Owing, however, to its having been applied somewhat indiscriminately, and occasionally used to indicate the sheath of Schwann or primitive sheath of the nerve-fibre, many histologists altogether deprecate the employment of the term, and substitute for it that of *perineurium*. I shall in this article continue to employ the term "neurilemma," since it is in common use in this country, it being, however, clearly understood that the laminated funicular sheath alone of the nerve is thereby meant.

primitive sheath of the nerve or sheath of Schwann; whilst enveloping all are the numerous laminæ composing the neurilemma. There is, moreover, altogether within the latter, a certain amount of finely filamentous connective tissue, which has long been known and described (Sharpey), in which the nerve-fibre lies imbedded. According to Key and Retzius this fibrillar layer (which they name the "endoneurium") is bounded externally, next to the neurilemma, and perhaps also internally, next to the sheath of Schwann, by a delicate stratum of flattened cells.

They further show, and it is not difficult to confirm the observation, that the lamellæ which compose the neurilemma (perineurium) agree in structure with the coats of the Pacinian, each lamella consisting of an inner and outer bounding layer of flattened cells enclosing fibres between them, the only difference being that in the case of the neurilemma the interstitial fluid is either absent or inconsiderable in amount. Moreover, the number of layers is far greater in the capsular envelope of the Pacinians.

Tracing now the continuity of these various parts of the entering nerve with the parts of the Pacinian corpuscle, we find, in the first place, the axis-cylinder of the nerve becoming directly continuous with the central fibre of the corpuscle (fig. 2). The medullary sheath, on the other hand, terminates, under ordinary circumstances, as soon as the nerve enters the core; more rarely, as we have seen, it continues to surround the axis-cylinder in its passage through the core. It certainly does not expand to form the core, as has been sometimes supposed, for in the first place the core is not blackened by osmic acid; and in the second place, when the axial fibre retains its medullary sheath, this exhibits an entirely different appearance from the surrounding core, from which it is distinctly marked off. To take next the primitive sheath or sheath of Schwann. This is more or less closely applied to the medullary sheath of the nerve just before it reaches the core, but then (fig. 2, *p s*) appears to open out and to pass to the exterior of the core, running at first apparently between the outer and inner parts of the core, but at length becoming lost to view. So that the main part, at least, of the core, since it lies within the prolongation of the sheath of Schwann (so far as this can be traced) between it and the central fibre, corresponds with the delicate protoplasmic layer which lies between the sheath of Schwann and the medullary sheath of a nerve-fibre. The outermost portion of the core, on the other hand, is distinctly continuous with the fine connective tissue in which the nerve-fibre lies embedded within the neurilemma; indeed, this tissue loses in great measure its fibrillated appearance as the nerve-fibre approaches the core, and exhibits a confusedly curdled aspect, which seems due to the presence of a number of nuclear bodies like those above described in the outer part of the core (see fig. 2).

The continuity of the outer layers of the Pacinian with the corresponding layers of the neurilemma may be readily observed even in the fresh condition; moreover, in silvered preparations the layers of flattened epithelioid cells which bound them are distinctly traceable spreading out from the stalk over the body of the corpuscle (Plate IX, fig. 1). In teased preparations also the whole of the entering nerve and its neurilemma may occasionally be plucked away, with those layers of the capsular envelope which are continuous with the neurilemma adhering to it. The more internally situated coats of the Pacinian seem, on the other hand, to be superadded;[1] near the stalk end of the corpuscle they commence abruptly, being attached to the innermost part of the neurilemma (Plate VIII, fig. 2); this is then prolonged around the core to form the innermost layer of the capsular envelope, sometimes even a little beyond the core, enclosing a prolongation of this; and the inner coats are again united with it at the further end, so that they form with the enclosed core a tolerably compact mass which it is easy to isolate.

The observations here recorded are in part founded upon preparations made by Mr. H. Price, student at University College.

List of Authors referred to.

Henle and Kölliker.—"Ueber die Pacinischen Körperchen an den Nerven des Menschen und der Säugethiere," Zurich, 1844.

Jacubowitsch.—'Comptes Rendus,' l. p. 859, 1860.

Ciaccio.—"Beobachtungen ueber die Pacinischen Körperchen aus dem Mesenterium der Katze," 'Centralblatt für die medicinischen Wissenschaften,' 26, 1864.

Hoyer.—"Ein Beitrag zur Histologie der Pacinischen Körperchen," 'Archiv für Anatomie,' 1864.

Michelson.—"Zur Histologie d. Vater-Pacinischen Körperchen," 'Schultze's Archiv,' v. 1869.

Grandry.—"Recherches sur les Corpuscules de Pacini," &c., 'Journal de l'Anatomie,' vi.

Axel Key and Retzius.—"Studien in der feineren Anatomie des Nervensystems," 'Schultze's Archiv,' ix.

A. Budge.—"Einige Untersuchungen ü. das Verhalten der Nerven in den Pacinischen Körperchen," &c., 'Vorläuf. Mitth. Centralblatt,' 1873.

Sharpey.—'Quain's Anatomy.'

[1] According to K. and R. it is the *outer* layers that are superadded.

Some Account *of* Modern Researches *into the* Nature *of* Yeast. By A. W. Bennett, M.A., B.Sc., F.L.S., Lecturer on Botany at St. Thomas's Hospital.

The long-received hypothesis that yeast is genetically connected with various species of mould has been subjected to severe criticism by de Bary,[1] and still more recently by Reess,[2] who have clearly shown that we have at present no sufficient reason for assuming a genetic connection between the two groups of organisms. Since his discovery of the occurrence of ascospores in beer-yeast, Reess has, on the contrary, endeavoured to establish the claim of ferment-fungi to be considered as organisms *sui generis* allied to *Endomyces* and *Taphrina* (*Exoascus*).

Reess set himself to investigate the problem whether the vegetative form of *Saccharomyces* which occurs in fluids susceptible of alcoholic fermentation embraced its whole course of development, or whether when removed from these media it would exhibit other phenomena of growth and especially of reproduction.

The usual materials for the culture of fungi—fresh or preserved fruit—were unsuitable in this case on account of their natural richness in sugar. But slices, both raw and cooked, of potato, Kohl-rabi, Jerusalem artichoke—and, notwithstanding its containing sugar, of carrot, proved suitable. On the surfaces of these slices the pulpy yeast which has settled—bottom-yeast—was spread in a layer as thin as possible. The superfluous water was then allowed to evaporate under a bell glass. The culture must be conducted in an atmosphere so regulated that it is always moderately moist. Drops of water must not be allowed upon the cultures, since with over abundant moisture the ordinary form of yeast will be reproduced, or other organisms will make their appearance, and clear the field. Bacteria will speedily get the upper hand and even infusoria, which will consume the yeast-cells.

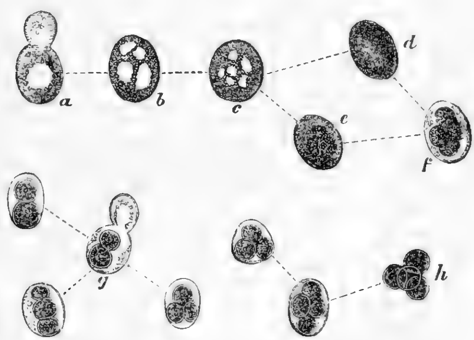
For the first two or three days the yeast presents much the same appearance as in a fermentible fluid of weak concentration. The cells, which contain much water and large vacuoles, bud. In twenty-four hours the edge of the layer of yeast advances in wavy projections $\frac{1}{2}$—$\frac{3}{4}$ mm. The cells themselves are roundish, seldom elliptic or spindle-shaped. No outgrowth of the yeast-cells into mycelial fila-

1 De Bary, 'Morphologie der Pilze,' 1861, p. 181.

2 Reess, 'Botanische Untersuchungen über die Alcoholgährungspilze,' 1870.

ments ever takes place, even when all the conditions suitable for the development of fungi exist. With the third day the vegetation of the yeast gradually diminishes, and on the fourth the cells are all separate from one another and no new buds are produced. After growth has continued for about four days, many of the cells—the older ones, containing but little protoplasm—die away and collapse. Others swell up till they attain a diameter of ·011 to ·014 mm. The large vacuoles have disappeared, the whole of the protoplasm appearing to be now interspersed with small vacuoles and drops of oil. On the fifth or sixth day, two, three, or four denser nuclei have become differentiated, almost all the remaining protoplasm being collected round them in fine granules, the nuclei becoming surrounded in the course of twelve or fourteen hours by a delicate membrane.[1] The original cell then encloses, besides an extremely small quantity of protoplasm and watery cell-sap, two, three, or four roundish daughter-cells from ·004 to ·005 mm. in diameter, formed by free cell-formation (fig. 1, *a, f*). When these are four in number they

FIG. 1.



form a cross or tetrahedron, like pollen-cells or fern-spores in their mother-cell. The membranes of the daughter-cells are always at first distinctly separated from the wall of the mother-cell; but subsequently the latter not unfrequently

[1] A very convenient method (devised by Professor Huxley) is to spread the yeast thinly on moistened cakes of plaster of paris and cover with a bell-jar. The yeast should be examined from day to day, and a little water poured under the cake when it becomes too dry. There is no trouble from bacteria or moulds, but the time required seems to be somewhat longer than with Reess's method. A 'culture' of this kind started on March 2 of the present year produced ascospores in abundance by March 13.

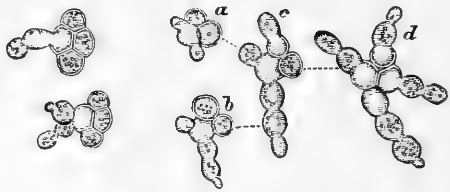
W. T. T. D.

becomes absorbed or coalesces with the former. The daughter-cells then appear united as if they originated from cell-division rather than free cell-formation (fig. 1, *g*, *h*).

The process of free cell-formation now described agrees in every particular which is capable of observation with the process by which the ascopores are formed in the asci of the Ascomycetes, as described by de Bary, Hofmeister, and Woronin. Reess, therefore, without hesitation, terms the mother-cells *asci*, the daughter-cells *ascospores*, and the *Saccharomyces* an *Ascomycete* in the broadest sense of the term.

The germination of the ascospores has been traced as follows:—When asci containing mature spores are placed in beer-wort, the spores begin at once to swell up strongly, but often unequally; their membranes coalesce with the wall of the ascus, if this has not already taken place. After fourteen or sixteen hours the true germination of the assemblage of spores commences, all those in an ascus, or only some of them, putting out knob-like protuberances. These protuberances become filled from the contents of the spore, and grow into a cell usually ovoid in shape, like the ordinary "buddings" from the *Saccharomyces*-cell. Larger cells are again formed from these by budding, followed by simple or branched filaments (fig. 2). The cells of these filaments are at first smaller

Fig. 2.



than the ordinary ones of *Saccharomyces cerevisiæ*; but when their number increases they become larger, and after a short time are indistinguishable from those produced in the ordinary way.

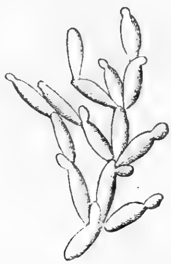
We have, therefore, under certain circumstances, in beer-yeast an alternation of generations; some of its vegetative cells developing into spore-forming asci or organs of reproduction; the germination of the ascospores producing again a generation reproduced by budding, similar to that from which it sprang.

[1] 'Bulletin de l'Académie Impériale des Sciences de St. Petersbourg' vol. xvii, 1872, p. 513.

Prof. J. Cienkowski has made an important contribution to our knowledge of the fungi connected with various fermentations.[1] The old theory, that yeast owes its origin to various species of mould—notwithstanding Reess's careful investigations—was still constantly cropping up, and was supported by such facts as the yeast-like outgrowths from the mycelium of *Dematium pullulans* and from the germinating filaments of *Taphrina* and *Exobasidium*, as well as the existence of similar structures as the gemmæ of *Mucor* and conidia generally. In the midst of these facts it would, indeed, seem very strange if *Saccharomyces* were the only organism of the kind that carries on an independent existence, and is not rather an element in the cycle of development of some form of mycelium-producing fungi. In order to determine the question, Cienkowski has carried out a series of experiments on the development of *Mycoderma vini*, Desm., which agrees in most of its phenomena with beer-yeast, and which can be easily cultivated quite free from admixture.

The white pellicle which rapidly forms on the surface of the most diverse organic fluids—urine, beer, milk, fruit-juice, sauer-kraut, cucumber-juice, infusions of roots, &c.—consists mainly of two essential ingredients, *Mycoderma vini*,

FIG. 3.



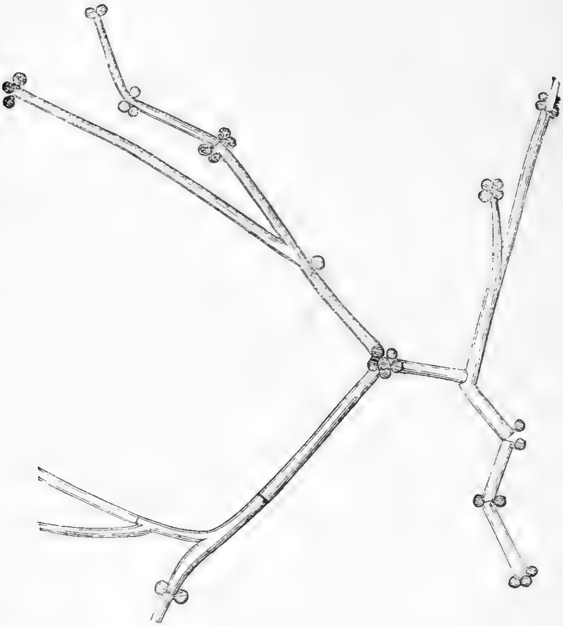
Desm. (fig. 3), and *Oidium lactis*, Fres., often accompanied by a branched mycelium, bearing at its septa single conidia or groups of them, and easily breaking up into separate cells ; for this organism he proposes the name *Chalara Mycoderma*[1] (fig. 4). In the present paper he traces the development chiefly of the *Mycoderma* and *Chalara*.

The cells of *Mycoderma* are most commonly connected into an arborescent form, each cell putting out a young "bud" from its apex, and subsequently a younger one from each side of

[1] Bonorden ('Handbuch der Mycologie,' p. 36, t. i, fig. 27) has given this name to a structure which, judging from his figure, is apparently the mycelium of *Oidium lactis*.

the base of the first (fig. 3[1]); this process being constantly repeated, the complete development exhibits a series of trichotomous branchings. It is usual, however, for only one of the lateral buds to be formed, either always on the same side or alternately on either side, and hence the plant acquires either a unilateral or zigzag appearance. Different forms are also produced according as the growth of the apical or the

FIG. 4.



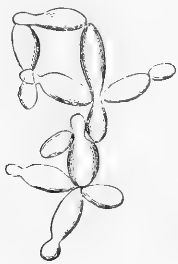
lateral buds predominates, and by the lateral buds sometimes springing at right angles and branching, occasioning a rosette-like structure (fig. 5). The size and form of the cells which compose the *Mycoderma* are subject to extreme variation, from very minute and spherical to very elongated and cylindrical; the buds generally becoming completely separated after a time. The contents of the cells also vary according to the composition of the nutrient fluid, being either hyaline and homogeneous, or very fluid and containing a few drops of oil or particles of protoplasm. The separate cells possess the power of putting out new buds when placed in a fresh nutrient fluid.

[1] In both figs., 3 and 5, the wood engraver has not made the constriction at the points of attachment of the buds to the cells sufficiently marked.

The form best suited for observation was found to be a group consisting of a larger cylindrical cell, bearing at both ends several smaller oval ones. These were found in abundance in the scum on the surface of sauer-kraut, and were removed into a fresh nutrient fluid consisting of white wine, diluted with one half water, a drop of which was examined under the microscope.

After from twelve to twenty-four hours, the cells put out a number of filaments, which were not unfrequently branched, and in which a septum soon made its appearance, the cell becoming bent at the spot where the partition-wall was formed, and breaking up into two cells. The first bud appears after a time at the apex of the uppermost cell, in the form of a papilla, which in the course of an hour grows so rapidly in length and breadth as to equal or even exceed the parent-cell. A similar papilla then appears at the apex of the next lower cell, or the outer side of the bend, which develops

FIG. 5.



in the same manner; and by the repetition of this process the more or less regularly zigzag form so characteristic of the species is produced.

The course of development is not always so simple as this, the cells themselves sometimes branching repeatedly, and producing a mycelium like that of mould still attached to the original parent-cell, the branches again ramifying in a complicated manner.

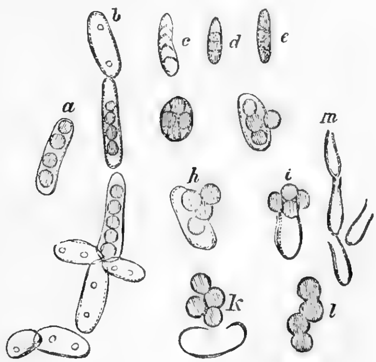
The properties of the nutrient fluid appear to exert considerable influence on the development of the cells of the *Mycoderma*. Where the amount of nutriment is small, the filaments are usually short and not partitioned, the knee-like bendings being also not developed; removal into a fresh nutrient fluid induces a new cycle of development. The arborescent form, which results from the production of a number of buds which do not become divided off by partition-walls, is especially prevalent when the deve lopment has been proceeding for a long time on the surface of the fluid. An abundant supply of the nutrient fluid appears especially conducive to the development of the mycelium; the long-continued action of the air to that of the buds. When developed in dilute wine beneath glass, the *Mycoderma*-cells produced beautiful mycelia, which appeared to attempt to reach the air. As long as the mycelium continued to grow in the fluid it consisted of very long cells and branches with but very few buds, while where the plant came in contact with the air the cells became shorter, the production of septa almost entirely ceased, and the arborescent form, consisting of unpartitioned buds, displayed the greatest perfection. In order to determine still further the influence of external conditions on the mycelium of *Mycoderma*, some pieces which were not producing buds were removed from the sauer-kraut scum to an infusion of carrot in which the formation of mould had been prevented. After the lapse of about two days the filaments had become divided by a number of septa into short cells, and buds began to develop from the free apex. The filaments eventually broke up more or less completely into fragments at the septa, the filaments becoming constricted quite independently of the septa.

The mycelium of *Mycoderma* bears so strong a resemblance to *Oidium lactis*, and to the mycelium of *Chalara* about to be described, as often to be distinguished from them only with difficulty; especially when, as is often the case, the three grow intermixed in the same solution. But notwithstanding this resemblance, the three organisms are essentially distinct, and possess widely different properties. The zigzag filaments of the *Mycoderm* mycelium put out buds; from those of *Chalara* conidia become detached by constriction; the filaments of *Oidium* develope into hyphæ, which produce chains of conidia by segmentation. The attempts of the writer to cause the latter to produce buds or to form conidia by the process of constriction, so characteristic of *Chalara*, always failed.

To sum up the phenomena now described:—*Mycoderma vini* exists in two vegetative conditions; the mycelium, and the budding form. In the first condition the branches are the result of lateral outgrowths from the cells, which grow uninterruptedly at the apex; the cells themselves continue to grow in length, and become segmented by septa. When the mycelium is about to pass over into the budding condition, on free access of air, it becomes broken up by numerous septa or constrictions, the growth of the cells then entirely ceasing. In this condition the buds are also the result of outgrowths of the mother-cell, but only a small portion of the latter takes part in their production. The bud has only a limited power of elongation, and becomes separated from the mother-cell not by a septum but by constriction, although a line of demarcation between the two modes cannot be accurately laid down.

The researches of Seynes,[1] and Reess,[2] show that under certain circumstances endogenous cells or ascospores are produced by *Mycoderma* and *Saccharomyces*. Their formation is induced by a very poor nutrient fluid, or by placing the organisms on a solid substratum, such as slices of potato or carrot. Cienkowski has confirmed the result in both cases. *Mycoderma vini* placed on boiled pieces of carrot, grew luxuriantly for some days. The ascospores first make their appearance after about a week, if the organism is not entirely overgrown by *Mucor*, *Oidium lactis*, &c. They occur in small isolated cells as well as in those still in connection with the filaments (fig. 6 *a*, *b*); but were never

Fig. 6.



observed in those that had attained any great length. Their minute size (0·004 mm. in diameter) rendered it difficult to observe the manner in which they were formed; apparently they are produced, not by free cell-formation, but by subdivision of the entire contents of the cell. In the cells in which the ascospores are about to be formed the contents of the cell become denser, and then split up into four plates, or into as many wedge-shaped portions (fig. 4 *c*, *d*, *e*). The

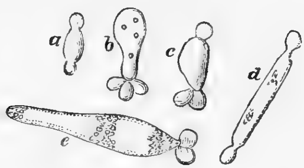
[1] "Sur le *Mycoderma vini*," 'Ann. des Sci. Nat.,' 5th series, 1869, vol. x.
[2] 'Botanische Untersuchungen,' p. 10.

portions finally become rounded off, but remain in most cases united in a row or tetrahedral heap, less often lying detached within the mother-cell. It is most probable that when mature the ascospores escape of their own accord from the mother-cell, but the mode in which the exit is made is not accurately known. Sometimes they are found attached to one another at the apex of the empty mother-cell; at other times projecting from a wide lateral slit, and when floating free in the fluid are either isolated or still united (fig. 4, *g*, *h*, *i*, *k*, *l*). The empty mother-cells are even occasionally found still united into short filaments (fig. 4, *m*). The further development of the ascospores in *Mycoderma* Cienkowski was unable to trace; Trécul's assertion[1] that hyphæ proceed from them is however very probable.

We now pass to the second constituent of the pellicle, the *Chalara Mycoderma*.

The *Chalara* frequently makes its appearance in the form of small spherical cells indistinguishable from those of *Mycoderma* and intermixed with them, and bearing at their two extremities pear-shaped papillæ (fig. 7), or not un-

Fig. 7.



frequently emitting long branched filaments like those of *Mycoderma*. In the latter case septa are formed, as well as new branches from lateral outgrowths, the filaments finally breaking up into loosely connected zig-zag rows, small cells being even formed at the extremities, so as to complete the resemblance to the filaments of *Mycoderma*. The essential distinction between the two consists in this; that in *Chalara* a number of conidia become detached in succession at one and the same spot, while this never occurs in *Mycoderma*, in which, if several cells are produced at the extremity of a parent-cell, their origin is not the same, one being apical and the second lateral, the succeeding ones springing from the base of the earlier ones. It was the neglect to observe this

[1] "Observations sur la levure de Bière, &c.," 'Ann. des Sci. Nat.,' 5th series, 1869, vol. x, p. 13.

distinction that caused Hoffmann[1] to make the erroneous assertion that the yeast develops into a fructifying mycelium.

The mode of formation of the conidia is a point of great importance in the development of *Chalara*. This can best be followed out in small pieces of the mycelium consisting of but a few cells. The cell puts out a pointed lateral papilla (*sterigma*) (fig. 8, *s*) below the septum, the extremity of which gradually swells up and becomes separated as a conidium. This is then pushed aside, and a new conidium produced from the papilla, this again making room for a subsequent one, and so on. In this manner six conidia were separated from a single papilla in the course of two days, the process taking place simultaneously at both ends of the cell; and the aggregations of conidia characteristic of *Chalara* being thus formed. The development generally advances from the base of the filament

FIG. 8.

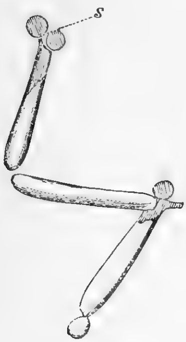
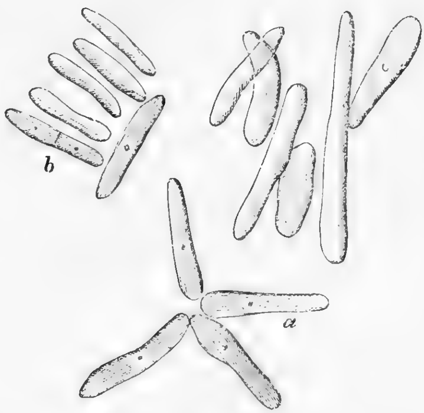


FIG. 9.



acropetally. The contents of the conidia are usually denser than those of the parent-cells; their diameter is about 0·004 mm. The cells of the mycelium-filaments are slender and of smaller diameter than those of the two other yeast-fungi, and usually branch dichotomously. The branches are produced in acropetal succession as lateral outgrowths from the cells, but occasionally from their centre. Their contents vary according to the conditions of growth; as in *Mycoderma*, they contain a number of vacuoles, and often masses of protoplasmic granules collected into transverse bands.

The *Chalara* mycelium is pre-eminently distinguished by

[1] Berkeley, Introd. Crypt. Bot. p. 242.

the facility with which its cells become detached, the disintegration advancing from the base towards the apex. The detached cells are usually cylindrical, but may assume the most various forms—spherical, fusiform, oval, &c.; this change of form being especially prevalent when the mycelium is transferred to a new nutrient fluid.

In addition to the form of *Chalara Mycoderma* now described, another variety, or possibly a different species, was observed in pellicles of yeast that had remained undisturbed for a considerable time where the nutriment was abundant, and was characterised by being composed of much stouter cells more firmly united. The separation of conidia takes place in this form only from terminal cells; and they remind one, from their crowded and erect position, of a pencil of *Penicillium*. The tendency of the cells to become detached from one another appears then to be confined to this separation of conidia. No intermediate forms were observed between the two varieties, nor could one be transmuted into the other.

As far as the cycle of development of *Chalara* is at present known, it is completed by the formation and germination of the conidia. They usually develop into oval or cylindrical cells in which state they remain if the amount of nutriment is insufficient; but when transferred into a fresh nutrient fluid, they put out after some hours long filaments, which develop according to circumstances into connected mycelia, or break up into cylindrical cells from which conidia are detached.

The development of the pellicle can be best watched on infusions in which various vegetable substances, especially fragments of roots, are decaying under water. When access of air is unimpeded, it commences to appear in a few days in the form of isolated branching cells mixed with cylindrical bent mycelial cells either detached or united into stars or zig-zag rows, or the whole field of view is occupied by parallel filaments (fig. 9, *a, b*). The cells vary greatly in diameter as well as in the nature of their contents. Very often they contain a number of vacuoles, enclosing particles of protoplasm, which closely resemble nuclei. "Buds" of various lengths, are then formed at the ends of particular cells which then separate as detached cells; and filaments are also produced, many of the cells in which are empty. The more conspicuous the pellicle the smaller is the proportion of the branching mycelium, the larger the proportion of the arborescent form. The branching mycelium appears to belong mainly to *Mycoderma*, the arborescent form usually to *Oidium lactis*, less often to *Chalara*. The slenderer filaments must usually be referred to *Chalara*, although not with certainty, as the cells of *Oidium lactis* and of *Mycoderma* vary widely in diameter.

It is not very often that all three fungi are produced together; the *Chalara* being the one most frequently wanting. They are probably all derived from the solid substance used for making the infusion, where they either occur as such, or are developed from conidia, mycelial cells, or ascospores, when water is poured on to it. When the fluid is very clear, as in the case of wine, the first traces of pellicle consist entirely of *Mycoderma* cells, followed invariably by *Oidium lactis*. The three forms appear to maintain their constancy under all conditions. In fluids in which alcoholic fermentation has taken place, Cienkowski found all three. There can be little doubt that the various species described by Reess under the names of *Saccharomyces apiculatus*, *pastorianus*, &c., are all forms of *Mycoderma vini*. Whether the cycle of development of *Saccharomyces* is as limited as Reess supposes, or whether it may ultimately be found to include *Oidium lactis* and *Chalara*, may still be considered an open question. It must be left also for future researches to determine how far the cycle of development of *Saccharomyces* (*Torula*) *cerevisiæ* corresponds to that of *Mycoderma vini*.

The resemblance between the mycelia of the different yeast-fungi is so great as to justify the hypothesis of their identity. It must, however, be admitted that at present we do not know of a single fact which places beyond doubt this extremely probable hypothesis. Very early in his researches Cienkowski apparently found *Chalara*-mycelia which had put out *Mycoderma*-buds from their branches as well as from the closely connected cells, and at the time considered this fact to establish conclusively the genetic connection of the two fungi. He had not, however, then learnt the difficulty of distinguishing between the two, and was subsequently led to believe that the filament represented a conidial form of *Mycoderma*.

There are also phenomena which appear to point to a connection between *Chalara* and *Oidium*. If both organisms are allowed to grow in damp air under cover-glasses, and only a very small amount of fluid supplied, it is sometimes observed that an *Oidium*-hypha suddenly developes into a very long slender filament, bearing a small spherical cell at the extremity, like *Chalara*. The thick part of the hypha then breaks up into the usual chain of conidia, which remains completely connected with the extremely elongated terminal cell. The mode of formation of the small spherical cell, whether by constriction as in *Chalara*, or by the formation of a septum as in *Oidium lactis*, is however still uncertain. There is also this fact in support of the identity of these two organisms; that *Chalara* branches are sometimes, though rarely, found so intimately attached to *Oidium* conidia, as to suggest the explanation that they must have been produced by the germination of the latter; but further investigations are wanted to determine this point.

Brefeld's researches[1] relate mainly to the Mucorini. Referring to the fact already known, that the spore of a *Mucor* produces a unicellular mycelium, from which is usually developed a single asexual sporangiophore, terminating in a sporangium (zygospores being occasionally produced in addition by a process of conjugation), he points out that in one respect different phenomena are presented by the minute *Mucor racemosus*.

If the spores of this species are sown on soaked bread or some other solid but moist substratum, the normal mycelia and sporangiophores are produced, but much more rapidly than in other species, the mycelium becoming separated into a great number of divisions, each producing a sporangiophore. If, on the other hand, the *Mucor* is plunged into a fluid, a modified developmental form results. Mycelia are first of all produced from the spores, which, after from twelve to twenty-four hours, become divided by septa, placed very irregularly, commencing from the ends, the cells thus produced being of very various forms and sizes. These cells rapidly become rounded off, their connection at their points of contact remaining very slight or being altogether destroyed. Their contents at the same time undergo a change; the vacuoles disappear; the protoplasm no longer consists of granules, but become homogeneous and strongly refractive; the cell-walls also become thicker; and the prevention of the formation of sporangiophores thus causes the uni-cellular mycelium to break up into a number of resting-spores which apparently replace them. They do not, however, long retain this condition; but after six hours or less put out germinating filaments resembling those produced from the ordinary spores; these filaments again break up into resting-spores, and the process is repeated as long as the supply of nutriment lasts. But in the later generations the germinating filaments become gradually shorter, passing gradually into a state closely resembling what we know as yeast (*Saccharomyces*). If the amount of nutriment is limited, only some of the cells assume the character of resting-spores,

[1] 'Flora,' 1873, No. 25, Sept. 1st.

the intermediate portions of the mycelium remaining empty, and the resting-spores do not become detached.

These bodies have long been known; Berkeley described them as long ago as 1838,[1] and Zabel and Bail[2] subsequently, giving them the unfortunate names "gemmæ," "Kugelhefe," and "Gliederhefe." Bail refers them to *Mucor*, which is, however, in his view identical with *Saccharomyces;* Hoffmann described them as "*Mucor*-hefe," distinguishing them from the ordinary yeast which according to him was derived from *Penicillium*; De Bary and Woronin referred them to *Mucor Mucedo* and *racemosus;* Reess and Fitz to *M. Mucedo* only.

Brefeld points out that the division of the originally unicellular mycelium of *Mucor* by septa is a phenomenon common to all the species when the mycelium is sufficiently large, the only difference in the case of *M. racemosus* being the great number of these septa, and the consequent very small size of the sporangiophores; the resting-spores being produced only when the formation of the sporangiophores is rendered impossible. He concluded, therefore, that if these cells (resting-spores) are removed from the fluid and exposed to air, they will produce sporangia in the ordinary way; and this he found to be the case. Under these circumstances a vigorous germination took place after from one to three days, a small sporangiophore and sporangium developing from each cell, their sizes varying according to that of the resting-spore which produces them, as also does the number of spores found, which varied from four to twenty-four. These sporangiophores presented in every respect the characters of those of *Mucor racemosus*. Each sporangium was furnished with a very small "columella," the nearly horizontal septum which separated it from the receptacle; the wall of the sporangium containing in some cases small deposits of calcium oxalate. From every spore proceeded an ordinary mycelium. It would appear therefore that the resting-spores of *Mucor racemosus* are portions of the mycelium destined for development into receptacles, but which pass into the resting state when air is excluded, and in this condition may produce the plant under water, but when exposed to air produce the normal receptacles.

Mucor racemosus is the only species that thrives under water, and hence the only one, with the exception of the nearly allied forms, that produces these peculiar resting-spores. In *M. Mucedo* small pieces of the mycelium were noticed,

[1] 'Magazine of Zoology and Botany,' vol. ii, p. 740.
[2] 'Flora,' 1857, p. 417.

resembling the resting-spores of *M. racemosus;* but they had no power of germinating; after a few days they burst and perished, a thick lump of protoplasm escaping from these, which soon became dark in colour.

The change in the form of the filaments of *Mucor racemosus* already mentioned, which makes the later generations so closely resemble true yeast, depends on the fact that under the influence of the fungus the infusion gradually becomes acid from its gradual saturation with carbonic acid. That it is the carbonic acid which causes the filaments to become shorter and more spherical may be proved by passing a stream of this gas through the fluid, when the effect stated is seen to be produced in the successive products of the same cell. If for the carbonic acid a stream of hydrogen gas is then substituted, the normal filaments are again produced.

Although other *Mucorini* do not possess the peculiarity of putting out yeast-like filaments under the influence of carbonic acid, the same effect is produced in some of them by vegetable acids. If *Mucor* (*Thamnidium*) *elegans* or *M. Mucedo* is grown in citron-juice to which a little citric acid is added, the spores swell up into large globes which put out a number of lateral offshoots. These shoots again assume a globular form; and the process goes on until the whole mass dies or puts out a few sporangiophores, this latter occurring but rarely. But if, before the mass perishes, as much ammonia is added as suffices nearly to neutralise the solution, the short spherical shoots again put out filaments of the normal form.

The liability of the *Mucorini*, especially *M. racemosus,* to assume the form now described, has been the source of numerous errors. Bail[1] and others assert that *Mucor* passes over, in a fluid capable of fermentation, into yeast (*Saccharomyces*). Reess[2] pointed out the inaccuracy of this statement, but himself asserted that in such a fluid as *e.g.* a solution of grape-sugar, *Mucor Mucedo* and *racemosus* assumed a yeast-like appearance. This assertion is again not correct, since in such fluids both these species produce only the normal germinating filaments, which are renewed from the periodically formed resting-spores, and the filaments produced from these assume a more and more yeast-like appearance as the solution becomes gradually saturated with carbonic acid. The assumed genetic connection between *Mucor* and *Saccharomyces* is

[1] 'Mittheilungen über das Vorkommen u. die Entwicklung einiger Pilzförmen.' Danzig, 1867.

[2] 'Alcoholgährungspilze.' Leipzig, 1870.

therefore disposed of. The genus *Saccharomyces* is distinguished by the typical yeast-like form of its cells, which are almost globular, separable from one another, and possess an unlimited power of propagation. M. Brefeld has carried on a series of researches to determine whether, under different conditions, as free access of air or growth in a very thin stratum of a perfectly neutral solution, true yeast will ever develop into a filamentous form; but always with negative results. He was therefore unable to come to any other conclusion than that there was no genetic connection between *Saccharomyces* and *Mucor*. Under ordinary conditions the cells of *Saccharomyces* divide in the most irregular manner and to an unlimited extent, the newly formed cells separating, and repeating the process indefinitely. If the separate cells come into contact with the air without being able to grow, each cell is transformed into a sporangium with two or four spores; and this, if again immersed in a fluid, reproduces the ordinary yeast-cells. The cycles of development of *Mucor* and *Saccharomyces* present therefore many points of resemblance. The filiform cells of the one correspond to the spherical cells of the other, the resting-cells of the former having no morphological importance; both produce sporangia when removed from the nutrient fluid and exposed to air; those of the former being more complicated in structure than those of the latter. These considerations led M. Brefeld to conclude that the two genera are nearly related, and that *Saccharomyces* is a simple form of the *Mucorini*.

This view is opposed to the ordinarily accepted systematic position of *Saccharomyces*, that adopted by Reess, who looks on it as the simplest form of the *Ascomycetes*, and regards the yeast-cell as an ascus in which the spores are produced by free cell-formation. Brefeld maintains, however, that the term *ascus* can only rightly be applied to a sac which produces spores belonging to a sexual generation, the product of a fertilised *ascogonium*. To this process there is no resemblance in *Saccharomyces*. The production of the spores in a yeast-cell resembles in every respect that in a sporangium of *Mucor*. There occurs in this group every intermediate form between free cell-formation and cell-division. Brefeld believes that none of the lowest forms of vegetable life can fairly be referred to the *Ascomycetes*.

There seems but little hope of finally determining the systematic position of *Saccharomyces* by the discovery of any sexual mode of propagation. Even in the *Mucorini* the similarity of the fertilising cells to one another indicates the form of this process to be as elementary as possible; and it is quite possible that in *Saccharomyces* it does not exist at all.

The following scheme is proposed for a fresh classification of fungi:—The SCHIZOMYCETES form the starting-point,—unicellular fungi without fructification or sexual cells. Next to them stand *Saccharomyces* and *Mycoderma,* unicellular fungi, with fructification, but at present without sexual cells. They form the connecting link with the ZYGOMYCETES, filamentous fungi with fructification and sexual cells, the filaments in the vegetative condition being unicellular and unsegmented, and the two conjugating cells indistinguishable from one another. Near the *Zygomycetes* must probably be placed the MYXOMYCETES in a distinct series, characterised by the union, not of two, but of several similar cells. *Piptocephalis* (the zygospore of which undergoes simple division) forms the transition from the *Zygomycetes* to the unicellular and unsegmented *Peronosporeæ* and *Saprolegnieæ* on the one hand, and to the multicellular ASCOMYCETES on the other hand, which for the first time manifest a distinction of male and female cells. The *Ustilagineæ* and *Entomophthoreæ* must be considered provisionally as a supplement to the *Peronosporeæ,* the *Chytridineæ* as a supplement to the *Saprolegnieæ,* the sexual process being still undiscovered in these families. The passage to the *Ascomycetes* is through *Gymnoascus,* the higher forms showing a gradually more and more complicated receptacle produced by the process of impregnation, and surrounding the fertilised ascogonium. The receptacle is neither unicellular nor filiform, but of complicated pseudo-parenchymatous structure. From *Gymnoascus* the series proceeds towards the *Erysipheæ,* which furnish in *Eurotium* a passage to *Penicillium,* and thence to the *Tuberaceæ.* The *Erysipheæ* are also related to the *Pyrenomycetes* and *Discomycetes.* If we consider the ascus of the *Ascomycetes* as replaced by the spore-producing basidium, we get the *Basidiomycetes,* the most highly developed group of fungi. The receptacle of the *Basidiomycetes* is unquestionably of sexual origin, although the process by which it is formed is still unknown. The *Basidiomycetes* are divided into those which produce their spores in succession (æcidia) and those which separate them all at the same time,—the *Gasteromycetes, Tremellini,* and *Hymenomycetes.*

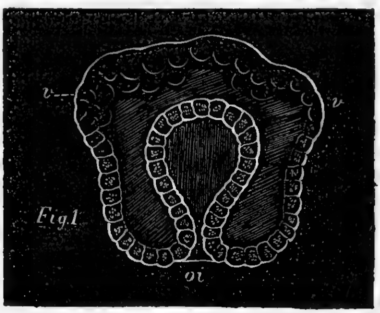
On the Invaginate Planula, *or* Diploblastic Phase *of* Paludina vivipara. By E. Ray Lankester, M.A.

At the end of last summer I had an opportunity of examining some embryoes of Paludina, in the laboratory of Exeter College, Oxford.

The formation of the primitive cell lining of the alimentary canal, or "endoderm," by invagination of the wall of a multicellular hollow sac, is particularly well seen in this mollusc. Leydig, who has given an account of the development of Paludina ('Zeitschrift für Wiss. Zool.,' Bd. II, 1850) observed the commencing invagination, and figured it, but he regarded it as the mouth. In this he was mistaken, since the mouth developes subsequently at the pole of the embryo opposite to the orifice of invagination. This orifice—which in the other mollusca in which I have observed it (viz. Pisidium, Limnæus, Limax, certain Nudibranchs, &c.) closes up at a very early period—does not (I am inclined to think) close up in Paludina, but remains open as the anus, and is fringed with cilia.

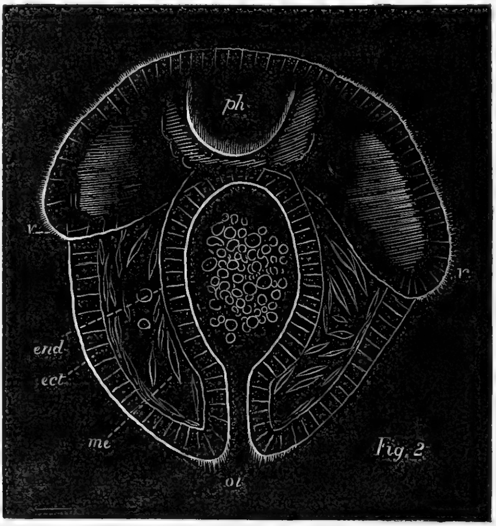
The woodcuts give two stages of this development, in which though they are merely outline diagrams, the sharpness of the cell-layers is not exaggerated. Paludina is remarkable for the clearness with which the cells of the primitive ectoderm and endoderm are presented in their earliest condition.

Fig. 1 shows the stage in which there are but two layers



of cells—the "diploblastic Planula" (see my remarks in 'Ann. and Mag. Nat. Hist.,' May, 1873); and, moreover, it shows this stage with a well-marked "orifice of invagination" (*o i*) an orifice which I have sometimes (*e.g.* in my paper on Limnæus), in deference to Professor Haeckel's terminology, spoken of as the "Gastrula-mouth," but which I propose no longer to speak of as "mouth." The diploblastic Planula of Paludina does not, then, arise by the formation of an endoderm by "delamination," as is the case in some embryonic histories (*e. g.* the Hydroid Polyps), but it arises by "invagination."

In Fig. 2, we see the embryo in a stage considerably



beyond this. The two primitive layers are as strongly marked as in the younger stage, but in addition we have fusiform and detached corpuscles disposed in the space (primitive body-cavity) between endoderm and ectoderm. These "mesoblastic" cells take their origin, I believe, partly from ectodermal, partly from endodermal parents. The velum (*v*) is now well developed and of large size relatively to the rest of the embryo. It subsequently becomes a curious little cap-like eminence above the mouth.[1] In the middle line the pharynx (*p h*) has appeared as a distinct involution, the widely open orifice of which is the mouth. It has not

[1] Leydig has well described the general form of the embryo at different stages. He has not, however, seen the "shell-gland," which I have detected in Paludina, thus extending the list of molluscan embryos provided with this problematical organ. I discovered this organ in Pisidium and the Nudibranchs in 1871. In Paludina the young shell has a chitinous boss or handle which fits into the "shell-gland," as in Neritina.

yet joined or broken into that portion of the alimentary canal formed by invagination from the anal pole. In the central dilatation of the invaginated alimentary sac granular matter and corpuscles are seen which attain subsequently a considerable development.

In the present communication I content myself with drawing attention to the facts afforded by Paludina confirmatory of those views as to the early development of the Mollusca which I have put forward in my memoir communicated to the Royal Society in February, 1874, as well as in a memoir on Limnæus published in October, 1874 ('Quart. Journ. Microsc. Science'), and which also are indicated in shorter notices in my papers in the 'Annals of Nat. Hist.,' 1873 (February and May). The main point is this—that in the Mollusca the endoderm or hypoblast originates by an *invagination*,[1] which, if the invaginated mass be large and contain food-granules and remain little or not at all broken up into cells, may be spoken of as a case of overgrowth or epibolé (Selenka). In this case the invaginated or overgrown mass gives rise to the endoderm or hypoblast by a segregation and cleavage *subsequent* to the invagination. If the invaginate mass contain a small amount of food-granules it will break up into cells *before* invagination, and thus form at once an alimentary sac by embolé (Selenka).

So far my observations and views with regard to Mollusca are but confirmatory of those of Kowalewsky relative to Euaxes and Lumbricus, and of Selenka (see his paper on "Purpura," 'Niederländische Archiv,' vol. i, 1872). But I have established the following important point with regard to those diploblastic Planulæ among molluscs which arise by embolé, viz. that the orifice of invagination either closes (***Pisidium***, ***Limnæus***, ***Nudibranchs***) or remains open as anus (***Paludina***). ***Possibly*** even in Paludina it closes and reopens after a short interval. Further, the neck of the

[1] In all animals this *invagination* of the primitive polyplast or mulberry sphere takes place sometimes in a more, sometimes in a less obvious manner, excepting in the Hydrozoa. In the Hydrozoa the endodermal layer forms by *delamination*, that is to say, it is formed by cell-division on the inner surface of a hollow sphere formed by a single layer of cells. Hence Planulæ are primarily divisible into delaminate and invaginate. They appear to arise by two varieties of the same process, differing chiefly as to the *time* at which the separation of the endodermal and ectodermal constituents takes place. From a comparison of the different conditions of the Planula presented by vertebrate animals, my friend Mr. Balfour has arrived at the conclusion that the Mammalian diploblastic phase arises by a modification of the process of invagination.

invaginate sac—the "pedicle of invagination"—becomes in all cases the rectum. The mouth makes its appearance subsequently and eats its way into the pre-formed alimentary sac from the opposite pole.

This being most positively the case in the Mollusca, I am led to raise the question as to whether the orifice of invagination really persists in *any* animal. Whilst I should not feel so much hesitation about a statement to the effect that it persists as *anus*, I would venture to ask for great certainty on the part of an observer who believes he has traced the *mouth* of any animal to this orifice. In the case of the Echinoderm-larvæ it is generally accepted that the anus is simply the persistent orifice of invagination. I am not aware that Agassiz—who most clearly points out the relation of the parts in question—had before his mind the suggestion that the orifice of invagination *may* close and a new opening subsequently appear at the same spot. I cannot avoid the conclusion that Kowalewsky's observation, also, as to the persistence of the planula's orifice of invagination—in the case of the Earth-worm—as "mouth," or rather as continuous with mouth, requires confirmation by an observer who shall distinctly keep the question as to identity of mouth and orifice of invagination before his mind. I make these remarks in relation to the statements of two most eminent and competent observers, rather as suggesting the need of renewed examination of this particular point than as believing that there is not a large probability in favour of their accuracy in observation.

If it should prove to be true that the orifice of invagination does *not* persist in the cases just alluded to, it appears to me that the planula (as I have defined it in my paper, 'Ann. Nat. Hist.,' May, 1873, p. 327), consisting of a hollow sac with two layers of cells forming its wall—and *not* the Gastrula—if by that term we are to understand "a planula *plus* a mouth" as Professor Haeckel does, is the important developmental form which can be recognised in all the Metazoa. The following words, which I have applied in my essay, already cited, to the Vermes, Echinodermata, Arthropoda, Mollusca, and Vertebrata, would then apply equally to all Metazoa. "The primitive orifice of invagination (mouth of the planula) does not persist either as mouth or, as has been erroneously supposed, as anus, but becomes entirely closed up, and a new mouth and an anus eat their way into the gastric cavity from the exterior" (p. 330, loc. cit.). There would not in this case be any animals which could be classed as retaining a primitive mouth. In all alike the mouth would be a late opening, which breaks into the already formed digestive cavity, as is well known to be the case in all the Hydrozoa, and in the higher Metazoa which have been specially examined on this point. Whilst there is room for much doubt in favour of the anus sometimes coinciding with the orifice of invagination, there is most pressing need for a re-examination of the asserted coincidence of the mouth with that orifice in the case of Actinia and Lumbricus. Finally if it should appear that the coincidence does occur in Actinia as to mouth, and in Echinoderms and some Molluscs as to anus, this would but make the mouth of the anus-less Cœlenterata identical with the anus of higher animals, in fact, it would have to be distinguished as a mouth-anus or *or-anus*. It would, then, seem inconceivable that an animal such as the earthworm, having an anus, should also have a mouth identical with the orifice of invagination, that is, with the anus of closely allied animals.

The orifice of invagination of those Planulæ which exhibit it requires a short and expressive name which shall avoid all implications as to its possible relations to mouth and anus. I propose to call it the *blastopore* (the pore or aperture in the blastoderm). This term applies both to the orifice which results from the ingrowth of the endoderm in embolé as well as to the gradually narrowing margin of small cells which extend over the larger cells in epibolé, since embolé and epibolé are but two extreme forms of one and the same process and are connected by intermediate forms. Another term which I think may be used with advantage is that of "residual yelk" in place of the misleading term "food yelk," or *nutritive* yelk-cells or spheres. I have proposed and used this term in my paper communicated to the Royal Society in February, 1874, to designate that larger and *comparatively* quiescent portion of the egg which becomes differentiated by the separation at one of its poles of a more active smaller portion of *segregated* yelk. The "residual yelk" may be very large and exhibit no cleavage, or it may cleave to a limited extent. By the use of the term "residual yelk" we avoid the implication contained in the term "food-yelk," or "nutritive yelk-spheres," of an absence in this part of the egg of material which can form structure. Not to mention other indications of the same fact, the recent observations of Götte on the chick, of Balfour on the shark, of myself on Cephalopods[3]

[1] I drew attention to the 'autoplasts' of the residual yelk of the Cephalopods, in February, 1873 ('Ann. and Mag. Nat. Hist.'). Owsjannikow ('Centralblatt,' March 13th, 1875) has recently recognised 'autoplasts' in the egg of fishes.

and other Mollusca, have shown that the residual yelk does contain formative and not purely nutritive material. It is in fact, in function, as well as morphologically, the equivalent of the invaginated cells of embolic Planulæ. The structure-forming protoplasm is there, but it is so enormously distended with nutritive granules or molecules that it often cannot cleave at all, sometimes to but a limited extent, and then, by a late segregation similar to that by which it gave rise to the first cap of formative protoplasm, it sets free at one or at many points the corpuscular elements which constitute the tissues derived from endoderm or hypoblast.

The term "food-material" or "nutritive material" I propose to apply to those granules and molecules (the deutoplasm of Van Beneden) with which the protoplasm of the residual yelk is gorged, as an Amœba may be gorged with solid particles of food.

Without entering into further explanations of terms I subjoin a condensed statement of some of the important variations presented by Planulæ.

A. The endoderm is separated by fission from the inner surface of a series of cells which form a hollow polyplast or blastosphere—

=Delaminate Planulæ.

These are at present known only in the Hydrozoa and the Calcareous Sponges (?).

B. The cells of the polyplast or blastosphere (mulberry-form, morula) do not individually divide each into an ectodermal and an endodermal cell, this separation having been already effected in the first cleavage of the egg. The single-layered blastosphere or polyplast consists of two hemispheres or areas constituted respectively by the future ectodermal cells and by the future endodermal cells (or their parents). By difference in direction of growth the latter becomes enclosed within the former—

=Invaginate Planulæ.

These latter may present, as extreme forms of one and the same process, connected by intermediate forms—

1. Relatively little or no difference in the amount of food-material incorporated in the cells of the ectodermal and the cells of the endodermal area of the polyplast, and accordingly an equality in the size and activity of those two sets of cells. In this case the endodermal cells become tucked or pushed into the cavity (segmentation cavity) of the polyplast, forming a follicular depression (the primitive gastric cavity), the margin of which constitutes a hole or orifice called

the blastopore. The blastopore rapidly narrows and closes up. The anus subsequently appears as a new perforation at the point corresponding to the cicatrix of the blastopore. In some cases it is possible that the blastopore persists as the permanent anus. It is not proved in any animal to persist in any other relation.

=Embolic Invaginate Planulæ.

These have been observed in the case of Amphioxus, Ascidians, many Molluscs, Sagitta, Echinoderms, and many Worms.

2. Or from the first commencement of the post-seminate development of the egg there is a relatively very much larger amount of food-material incorporated with the endodermal portion than with the ectodermal portion of the segmenting polyplast, so that the latter may be spoken of as the "segregate" or "active yelk," the former as the "residuum" or "residual yelk." The residual yelk (endodermal portion of the polyplast) generally is but little or not at all segmented, and is *overgrown* or enveloped by the advancing cells of the active segregate yelk (ectodermal portion of the polyplast). The blastopore closes early, and has never been supposed to persist either as anus or as mouth.[1] The subsequently developing anus sometimes corresponds approximately in position with the cicatrix of the blastopore.

=Epibolic Invaginate Planulæ.

These have been observed in the case of many Molluscs, many Vertebrates, the Ctenophora, and certain Worms, and certain Arthropods.

In conclusion, I may touch on another matter to which attention is drawn by Metschnikow in an article in 'Köll. und. Sieb. Zeitschrift' for 1874, and by Professor Huxley in an article on the classification of animals (this Journal, Jan., 1875). In Echinoderms and in Sagitta—most clearly in the latter—the body cavity commences as a diverticulum of the alimentary canal, in fact, as a gastro-vascular space, comparable to that space in Cœlenterata. At the same time Schulze (F. E.) has described in Sarsia the formation of a space in the gelatinous tissue of the disc by the simple splitting of the deep layers of the tissue. You have in the latter an undeniably "schizocœlous" condition, in the former an "entero-cœlous" condition, to use Professor Huxley's terminology. I wish now very briefly to point out that, viewing the

[1] Except by Selenka, who considers that it becomes the mouth in Purpura.

matter genealogically, it is quite possible that by the obliteration of the lumen of gastro-vascular outgrowths of the primitive alimentary canal a large bulk of cellular elements should be furnished to the so-called " mesoblast " from the hypoblast, and that subsequently this solid mass of cellular elements should by splitting develop a cœlom. In this way it is conceivable that the schizocœlous condition might develop from the entero-cœlous and gradually lose all trace of its ancestral origin further than is afforded by the derivation of some mesoblastic cells from hypoblast. At the same time there is much to be said in favour of the schizocœlous condition being an aboriginal one, since we see that it really can make its appearance (in a rudimentary way) among Cœlenterata. The grouping of animals by Professor Huxley (loc. cit.) according to the actual mode of formation, and supposed corresponding ancestral distinction, of the body-cavity, which term has, according to his view of the matter, been applied to three very distinct kinds of cavities, cannot but draw increased attention to the actual and possible relationships of the spaces which develop between endoderm and ectoderm. Until there are facts to hand to show that it *is more* probable that the varieties of body-cavity in such groups as Mollusca, Vertebrata, and Chætognatha, are of distinct origin in each cases than that they are due to modification of one ancestral cavity, one is disposed to adopt the hypothesis of *uniformity* as the simplest and the least likely to lead into difficulties.

On the Colouring Matter *of Bonellia viridis.* By H. C. Sorby, F.R.S., &c., Pres. R.M.S.

Some months ago my attention was called by Mr. E. Ray Lankester to a green colouring matter which he had obtained when at Naples from the above-named annelid. I immediately saw that it was a substance of great interest, and in order that I might be able to study it carefully Mr. Lankester kindly gave to me a large portion of the material he had collected. He has since furnished me with the notes and drawings which he made at the time, and with the following description of the animal, which it would be well to give before entering into the consideration of the optical characters of the pigment itself.

Bonellia is a worm which lives in holes in calcareous rocks.

Its body is globular and lies in a large cavity in the rock, whilst a long fan-like proboscis is exserted from a fissure connected with the cavity. Consequently *Bonellia* is not exposed to sunlight. The green colouring-matter occurs in clusters of fine granules dispersed in the tegumentary tissues, and is apparently deposited in the protoplasm of the epidermic cells. The green colour is of so deep a tint that the animal appears to be nearly black. The drawing of the spectrum of this substance when in the living animal, made by Mr. Lankester, agrees so closely with what can be seen in the alcoholic solution, which I have studied, as to show that no decided change has taken place, although it has been kept exposed to the air for more than five months, and thus it appears to be a compound of very considerable permanence. The position and relative intensity of the bands shown in the drawing also differ no more than was probably due to the colouring matter being associated with some oil, and not dissolved in the solvents used in my experiments.

In all my previous publications I have expressed the position of the absorption-bands seen in the spectra of coloured substances by referring them to a scale furnished by the black interference bands seen in the spectrum of the light passing through a plate of quartz between two Nicol's prisms, the thickness of the plate being such that the Fraunhofer line D is $3\frac{1}{2}$, and the line F $7\frac{1}{2}$, or thereabouts. I still use this scale for actual observation, but it appears to me that for the future it would be far better if all writers on such subjects would express the position of the absorption by giving the length of the waves of light at that particular part of the spectrum in millionths of a millimètre. In order to be able to do this I have constructed a table of the wave-lengths of every part of my quartz scale, so that, after having measured the position of any absorption-bands, I can immediately express it by numbers representing millionths of millimètres of wave-length. The advantages of this system are that, not only is it a scale that all may adopt for general comparison, but, as I shall be able to show in some subsequent paper, most important relations can be shown to exist between the wave-lengths of different bands, which relations cannot be recognised if any other scale be adopted. I propose, therefore, in future to express the position and character of bands by millionths of millimètres of wave, and by printing under the numbers symbols to indicate the relative intensity of absorption, thus:

Very faint absorption	•
Quite decided ,, . . .	••
Dark and strong ,, . . .	— —
Black and very strong absorption . .	—

Now, by carefully discussing the wave-lengths of the centres of the absorption-bands in the spectra of substances which have a number of well-defined character, I find that they appear to be related to one another in the following manner. If the wave-lengths of a series of such bands, passing from the red end to the blue, be a, b, c, d, &c., the ratio between any consecutive pair is very closely, if not absolutely, the same; that is to say, $\frac{a}{b}=\frac{b}{c}=\frac{c}{d}$ &c. If, however, the complete spectrum be a, b, c, d, it does not by any means follow that all the bands are always present. In the case of some substances the spectra of the acid and alkaline solutions are related thus:

Alkaline solution . . .	*a*	*b*	*c*	
Acid solution		*b*	*c*	*d*

It also frequently happens that under certain conditions some of the bands, which in accordance with this law ought to be present, are absent, so that the spectrum may be, for example, a, c, d, and in other conditions of the substance (for instance, dissolved in some other solvent) the missing band may make its appearance at the true interval. It must also be borne in mind that without any considerable change in the general character of the spectrum the wave-lengths of the bands may vary very considerably, according to the nature of the liquid in which the substance is dissolved, or according as it is in a free state or in solution; so that we have to consider both the alterations in the position of any particular band, as well as the development of new bands. Very much remains to be learned in connection with this subject, and I do not yet feel quite certain that the above-described relations are the true law, or only a better approximation than any hitherto made.

Having now given such a short account of my general conclusions as seemed necessary for the subject before us, I proceed to describe the spectra of the colouring matter of *Bonellia,* which for convenience may be named *Bonelleine.*

Being green and fluorescent, and the spectrum showing a very well-marked absorption-band in the red—being, moreover, insoluble in water, but soluble in alcohol and in carbon bisulphide—it might at first be mistaken for chlorophyll, or might at all events be looked upon as a chlorophyll substance; but when more carefully examined it is soon found to differ completely from either blue or yellow chlorophyll or chlorofucine, which, according to my views, are the only genuine species of the genus chlorophyll hitherto described.[1] All of these are changed by strong acids into new substances, so that when the solution is subsequently neutralized the spectra are found to be totally unlike those of the original substances. On the contrary, on adding an acid to the green alcoholic solution of bonelleine the colour becomes purple, there is a great change in the spectrum, due to the removal of some bands and the greater development of others, but no other alteration, even after many days, and on neutralizing the acid the original spectrum is again seen just as at first, thus proving that no such decomposition takes place as in the case of chlorophyll. In this respect it resembles the well-known product of the action of acids on blue chlorophyll, but this latter differs from bonelleine in giving the same spectrum when the solution is acid as when it is neutral or alkaline.

Bonelleine also differs from the three different species of the chlorophyll group in the character of its fluorescence. The neutral alcoholic solution gives *two* bright bands, whose centres are at wave-lengths 643 and 588, whereas the chlorophylls give only one. The spectrum of the fluorescence of the acid solution of bonelleine gives a single bright band at wave-length 619, whereas that of the product of the decomposition of blue chlorophyll by acids gives *two*. These are such important differences that it seems desirable to look upon them as of generic value, though, at the same time, in the present state of our knowledge it would, perhaps, be premature to decide what characters should be considered sufficient to constitute a natural group, or, so to say, genus, of colouring matters.

Before describing the various spectra in the manner already explained, it would be well to give the wave-lengths of some of the principal Fraunhofer lines, so that the position of the absorption-bands may be better understood by those who have been in the habit of referring their observations to those lines:

A	760	B	686	C	656	D	589
E	527	*b*	517	F	486	G	430

The greatest number of bands that I have seen in any

[1] 'Proceedings of the Royal Society,' vol. xxi, p. 452.

particular solution of bonelleine is seven, but in the complete theoretical spectrum sixteen. On the whole, it seems to me the best to indicate the position of the absent bands by small figures and that of those present by larger, and to express the intensity of the absorption by symbols printed under the numbers of millionths of millimétres, as already explained. For the sake of simplicity I give only the theoretical positions, and merely say that in no case does observation differ from this theory by more than a millionth of a millimètre. In accordance with this system the spectra of the different solutions are as follows:

In carbon bisulphide—

643	630	**618**	606	**594**	582	571	560	**549**	538	**527**	517	507	**497**
—		••		••				•		••			— —

In alcohol, neutral—

662	649	**636**	624	**611**	599	**587**	576	564	553	542	531	**520**	509	500	**490**
•		—		••		— —						— —			— —

In alcohol, slightly acid—

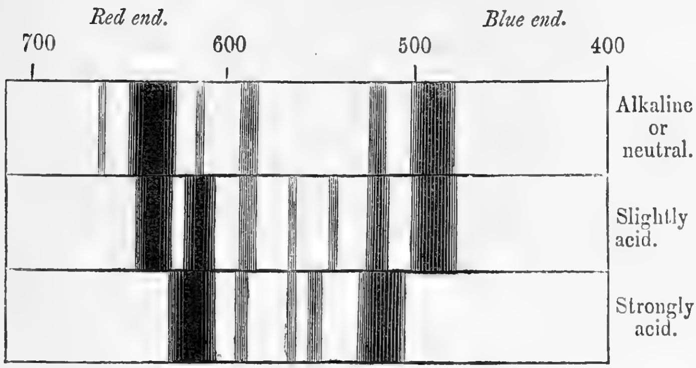
636	623	**611**	599	**588**	577	**565**	554	**543**	534	**522**	511	502	**492**
—		— —		••		••		••		•			— —

In alcohol, strongly acid—

617	603	**590**	577	**565**	**552**	540	529	**517**
—		••		••	••			••

It will thus be seen that when dissolved in alcohol the bands are raised towards the blue end by an interval of about seven millionths of a millimètre of wave-length, and that, whilst the faint band at 549 disappears, that at 527 is made darker when in alcohol. There is also a new faint band developed at 662. On adding a very little acid to the alcoholic solution the band at 662 vanishes, that at 611 is made darker, that at 587 fainter, two new bands are developed at 565 and 543, whilst that at 520 is made much more faint. On adding more strong acid the bands at 636, 543, and 492 disappear, those at 611 and 522 are made darker, and both moved in opposite directions more towards the centre of the spectrum, and a fresh band is developed at 551.

The character of the different spectra and the relation of the various absorption-bands will be better understood by means of the following figure:



Spectra of Bonelleine in Alcohol.

The numbers given on the upper side represent the wave-lengths of those parts of the spectrum in millionths of millimètres, and the scale on which it is drawn is 1 inch to 100 millionths, which appears to me to be a very convenient and suitable size.

A glance at the figure will at once show how some of the bands are common to both the alkaline or neutral and the slightly acid solution, whilst some are diminished in intensity or disappear, and others are made much more intense or are only developed when the solution is slightly acid. It will also be seen that the addition of more acid still further modifies the spectrum in a similar manner, and that the two principal bands represent two which are comparatively very feeble in the neutral solution, whilst the two principal bands in this latter have entirely disappeared. It will also be noticed that the addition of a strong acid lowers the bands at the red end somewhat towards the red and raises that at the blue end towards the blue, whilst the central band remains in the same position as when the solution is neutral.

It will thus be seen that, though the spectra of bonelleine are of an unusually complex character, they agree in a remarkable manner with the general principles which I have briefly explained, and furnish us with an admirable illustration of the peculiar laws connecting together the wave-lengths of the bands, and of the influence of solvents and of such foreign substances as weak or stronger acids. I cannot but think that the further application of this method of study to other substances will lead to a great increase of our knowledge of the relation between optical and chemical properties, and throw much light on many interesting questions connected with molecular physics and other branches of science; and it is this conviction which has made me anxious to give a complete description of the spectra of a substance which exhibits them to very great advantage.

NOTES AND MEMORANDA.

To the Editors of the Quarterly Journal of Microscopical Science.

Sir,—In the account of the discovery of the segmental organs in Elasmobranchs by Professor Semper, and myself, which appeared in the January number of your journal, one or two expressions are used, which might lead to an erroneous impression as to the priority of this discovery. This rests with Professor Semper, who published his first note on the subject in July, my own account, though entirely independent of his, not being published till October.

F. M. Balfour.

[What we said was that Mr Balfour was the first to *publish figures* establishing the fact of the existence of a series of openings into the body-cavity from the primitive kidney-duct of the Elasmobranchs. This, we believe, is true.]—Eds.

Amplifiers for the Microscope.—In the Biological and Microscopical Section of the Academy of Natural Sciences, of Philadelphia, January 4, 1875, Dr. J. Gibbons Hunt made a communication upon the subject of *amplifiers for the microscope,* in the course of which he remarked that from the time of the first observation by the aid of more than two convex lenses, an almost constant effort had been made by opticians to fit in the best intermediate glasses, and yet further improvement in this respect was confidently to be looked for. The amplifier which he had upon the table consisted of a concavo-convex lens, with its concave side turned towards the eye, and so placed within the body of the microscope as to stand at a considerable distance from the objective. This adjustment of position was best accomplished by having the amplifier screwed to the end of a tube arranged with rack-work in such a manner as to traverse six or eight inches, because we could thus compensate for a want of complete correction in the objectives employed.

The advantages obtained by using an amplifier were, in the first place, gain in magnifying power, as could be seen in his microscope upon the table, when with an amplification of 800 diameters, afforded by a four-tenth of an inch objective, he had on exhibition the navicula angulatum resolved into dots all over the field, which was apparently more than sixteen inches across. By the aid of an amplifier we also gain a greater focal distance, and an increase of flatness of field.

Amplifiers have been employed in telescopes for the past fifty years, but ten or twelve years ago they were only adapted to microscopes, in this city at least, by one or two amateurs. Subsequently, Mr. Tolles, of Boston, saw them in use here, and on his return home made one, apparently with gratifying success, as he has since kept them in stock.

Dr. J. G. Richardson inquired of Dr. Hunt whether, in his opinion, the four-tenth objective associated with his amplifier, as he had it upon the table, and eye-pieced so as to give a power of 800 diameters, was equal to his Powell and Leland's one sixteenth immersion lens, combined with the "A" eye-piece. Dr. Hunt replied that on histological work the results were not quite so good, but on pleurosigma angulatum he considered them fully equal. The combination of amplifier and objective which he used was, however, a merely accidental one, so that a skilful optician would probably be able to arrange the lenses more efficiently, and at a lower cost. Pigott's aplanatic searcher appeared to be a modification of the amplifier, but had proved so unsatisfactory in his hands that he had entirely laid it aside.

Professor Stricker on Pathology of Suppuration.—For some time past Professor Stricker, of Vienna, has been conducting a series of investigations on the pathology of suppuration of the cornea. An account of his results has been published in the December number of 'Stricker's Medizinische Jahrbücher' for 1874. Mr. D. J. Hamilton, who has been working on the subject of inflammation, during the present winter in his Laboratory, sends us the following account of the methods of procedure and the appearances met with. The cornea of the kitten is the most convenient for experimenting upon, for it is worthy of remark that the cornea of a young animal is more easily inflamed than that of an older one. The animal having been narcotized with a mixture of ether and chloroform, a small eschar is made in the centre of the cornea, with solid nitrate of silver. The animal is then left for twenty-four hours, by which time abundant inflammation has been excited around the cauterized spot. The entire cornea must now be stained with nitrate of silver whilst the animal is alive, for the appearances presented if the protoplasm is stained in the living state are very different from what are seen when the staining is performed after the animal is dead. To stain it properly the animal must be again narcotized, and then the solid nitrate of silver is rubbed over the entire surface of the cornea. When this is done in the living state all the layers become stained in a few minutes. The cornea is now cut out and placed in a weak solution of acetic acid and water for twenty-four hours. By this time it has swollen up and can be easily split into layers. When one of these layers is placed in glycerine and examined with a low power (No. 2 Verick), a cloudy zone is noticed surrounding the cauterized spot, while outside this the cornea appears to be normal. The inflammatory process does not affect the whole cornea, but is most marked at a short distance from the point of greatest irritation. And, now, if we examine this cloudy area with a higher magnifying power (No. 7 Verick, or No. 10 Immersion Hartnack), we can distinguish certain well-marked changes in the corneal tissue, and are thereby enabled to interpret their history The first noticeable phenomenon, and probably the earliest change that occurs, is a remarkable contraction of the processes of the corneal cells, so that instead of fine processes uniting the cornea-cells together we see a dense network with very little intercellular substance. In certain parts the contraction has gone so far that the cornea-cells are individually isolated. What next occurs, and is so clearly demonstrated as not to leave the slightest doubt on the subject, is fissiparous division of this dense network of cornea-cells and their contracted processes. The divided parts are at first irregular in shape, but when separated from the parent stem, as afterwards happens, become rounded, a nucleus is developed in their interior, and they become individual pus-corpuscles. In some places the divisions are extremely small, and, in these instances, it is probable that pus-corpuscles are not immediately formed; but that they remain as the granular material of fully formed purulent fluid. The intercellular substance next becomes disintegrated, and we have a microscopic abscess as the result. He has never found any evidence to show that the large numbers of pus-corpuscles seen in this point of suppuration emigrate from the vessels surrounding the border of the cornea, and is of opinion that the changes met with in the layers of the inflamed cornea are a prototype of what occurs in other tissues.

Professor Max Schultze.—A recent number of the 'Archiv für Mikroskopische Anatomie' contains a memoir of this lamented anatomist, from which we take most ot the following account. Max J. S. Schultze was born in 1825, at Freiburg, in Breisgau, and was the son of C. A. S. Schultze, at that time Professor of Anatomy and Physiology there,though shortly afterwards transferred to a similar post in Greifswald. In his youth, zoology was his favorite study, and music his favorite amusement; he attained also considerable proficiency in drawing, which was afterwards of great use to him. His medical studies were chiefly carried on in Greifswald, but for one winter he was a pupil of Johann Müller and Brücke, in Berlin. As a student, and in the early part of his career as an investigator, he devoted special attention to animal chemistry, and several of his earlier memoirs relate to this subject. In 1849 he obtained his medical degree, taking as the subject of his thesis (which received a prize) *De arteriarum notione, structurâ, constitutione chemicâ, et vitâ;* and was shortly afterwards appointed Demonstrator of Anatomy and *Privat-docent.* Even while thus engaged, zoology occupied the first place in his interest, and especially the marine fauna of the northern seas. His first important memoir on these subjects was that on the 'Turbellariæ,' published in 1851, with seven plates, and this, with his other published papers, secured for him a grant from the University of Berlin of the Blumenbach Travelling Exhibition, something corresponding, as we must suppose, to our Travelling Fellowships. To this period also belongs his important discovery of chlorophyll in animal organisms. The valuable opportunity afforded by his travelling pension was employed by Schultze in studying marine zoology on the coast of Italy, where both the Adriatic and Mediterranean seas supplied him with abundant material. It was here that he made the researches which were published in 1854 in the classical monograph "On the organisation of Polythalamia, with remarks on Rhizopoda in general;" a memoir which was not only important in its zoological aspect, but as afterwards forming the basis of Schultze's reform of the cell-theory.

In the same year he was made Extraordinary Professor at Halle, and married his first wife, who was his cousin. During the five years of his stay in Halle, he produced a remarkable number of important papers, among which must be mentioned his first great memoir on the electrical organs of fishes, and two papers on the termination of nerve-fibres in the organs of sense; both subjects which he afterwards made especially his own. We may also enumerate, as better known in this country, two zoological papers "On the development of arenicola piscatorum," and "On the natural history of the terrestrial planariæ," both of which were translated in the annals of natural history, and finally one on "Internal movements in certain diatoms from the North Sea," which was translated in this journal.

The reputation which, in spite of the, in many respects, unfavorable circumstances of the professorship at Halle, Schultze soon acquired, obtained for him in 1859 an invitation to the important chair of anatomy at Bonn, then vacant by the translation of Helmholtz to Heidelberg. It was here that he became especially celebrated as a teacher, both for the unstudied elegance of his style and the masterly skill of his practical demonstrations. His inaugural dissertation, *Observationes de retinæ structurâ penitiori*, was the first of his classical contributions to the study of the retina.

In the next year appeared an important memoir on Hyalonema, and another on Cornuspira, with remarks on the organization of Polythalamia (translated in the 'Annals of Natural History'), but in 1861 he published his first observations on the subject by which he will probably be best known to posterity, viz., the nature of the cell. This memoir, 'On muscle-corpuscles, and what one ought to call a cell,' appeared in the same year as Lionel Beale's lectures, and about the same time as researches of Brücke, having the same tendency. It is to those three investigators that we owe the modern doctrine of the cell; viz., the substitution for the conception of a cavity enclosed by a membrane, of that of a mass of sarcode or protoplasma, which, with some inconsistency, we call by the same name; and there can be no doubt that the share of Max Schultze in effecting this reform was very large indeed. The same line of investigation was carried on in his important work on the Protoplasma of Rhizopoda, and of vegetable cells published in 1863, and later on by observations on the movements of white blood-corpuscles, in which he was aided by his admirable invention of the hot stage. The new views were not accepted without an active controversy, in which Reichert was the chief defender of the doctrine of a cell-membrane.

The later researches of Schultze were chiefly in the same lines as those already mentioned, on the organs of sense, especially the retina, and the terminations of nerves, with some further memoirs on simple forms of life, and two or three papers on technical methods, in which he introduced the reagents now so well-known, iodized serum, osmic acid, and acetate of potassium. The 'Archiv für Microscopische Anatomie,' which has been since its foundation the chief organ of histological research in Germany was commenced in 1865, partly in consequence of the estrangement which controversy had produced between Schultze and Reichert, one of the editors of the 'Archiv für Anatomie und Physiologie.' It has certainly justified its foundation by its brilliant success. Besides his journal, the organization of the anatomical teaching at Bonn, and especially the building of a new Anatomical School, which is now one of the most splendid and complete in Europe, occupied the later years of his life. So engrossed was he in this task that he refused two brilliant offers of chairs at Strasburg, and at Leipzig. In 1872 the new building was finished, and in 1874 the professor occupied the dwelling-house attached to it, but a few days only after taking up his residence there he died suddenly of a perforating ulcer of the duodenum in his forty-ninth year. The loss to science in his untimely death can hardly be estimated. Certainly Germany never produced a more accomplished histologist. The list of his published memoirs extends to eighty-two, produced between 1846 and 1872. The 'Archiv' is to go on under the editorship of Professors V. la Valette St. George of Bonn, and Waldeyer of Strasburg.

The late Professor von Mohl.—Hugo von Mohl, born April 8th, 1805, was the fourth of five brothers, all of whom were men of note, either for public services or intellectual ability. His father was some time Minister at Wurtemberg for Home Affairs and Worship, while his mother, a person of exceptional gifts, was the daughter of Autenrieth, Finance Minister in the same State.

Von Mohl's early education was obtained at the Gymnasium of his native town, Stuttgart. In his nineteenth year (1823) he entered the University of Tübingen, where (in 1828) he graduated in medicine. In his inaugural dissertation (alluded to below) he clearly foreshadowed the course in science in which he was to pre-eminently excel. It was his father's wish that he should devote himself to surgery. This, however, was distasteful to him; and the intercourse into which he was thrown during the next few years with Von Martius, Zuccarini, Steinheil, and other botanists, soon determined the direction of his pursuits. In 1831 he contributed to the great work of Martius on Palms a memoir on the structure of the stems of those plants. In this year he was nominated first "adjunct" to the Botanic Garden of St. Petersburg, a post which, however, he did not accept, owing to his being appointed Professor of Physiology at Bern, whither he went in 1832. After the death of Schübler he returned, in 1835, to Tübingen as Professor of Botany in the University; and here he remained, notwithstanding many brilliant proposals tempting him elsewhere, till the time of his death. The interests of the University of Tübingen were matters about which he felt a keen solicitude, and the foundation of a Faculty of Natural Science in that University was essentially his work. In 1843 the Order of the Crown of Wurtemberg was conferred on him and he was ennobled. About this time he was obliged to make a prolonged stay in South Tyrol on account of delicate health. He recovered; but although a man of great stature and robust build, he appears, after he had accomplished his sixtieth year, to have fallen into chronic ill health. He suffered from pleurisy and attacks of diarrhœa. Eventually he became very reserved in manner and subject to giddiness. On the morning of Easter Monday, April 1, 1872, having been cheerful and well the night before, he was found dead in bed.

These particulars are derived from the memoir which appeared in the 'Botanische Zeitung' for 1872. Von Mohl was elected a Foreign Member of the Royal Society, March 26th, 1868.

In describing fully Von Mohl's scientific career and position, it would be necessary to write the history of vegetable histology. His work is practically coincident with the application of the higher powers of the microscope to the investigation of vegetable tissue. Confining himself almost exclusively to the higher classes of plants, from the group of Muscineæ upwards (and neglecting the Algæ, Fungi, and Lichens), there is hardly a point of any consequence in which some research or investigation of Von Mohl's is not the solid foundation of our present knowledge. The catalogue of Scientific Papers of the Royal Society enumerates 78 of his papers—not including various dissertations, some of which, along with a selection of the more important of his papers, were in 1845 collected and published in a quarto volume, under the title of "Vermischte Schriften." The list of his publications which accompanies the memoir in the 'Botanische Zeitung' gives the titles of no less than 90. Nor were his own labours the only way in which he contributed to the advancement of our knowledge of the minute anatomy of plants. In 1843 he commenced, in conjunction with Schlechtendal, the 'Botanische Zeitung,' a small quarto weekly periodical of eight pages, occasionally illustrated with plates, which he continued to edit till the time of his death. The volumes of this journal chronicle, year by year, the gradual development of the microscopic study of plants, a field in which (doubtless in no small degree owing to the example of Von Mohl) German science has reaped a more abundant harvest than that of other nations. No one can fail to be struck with the thorough character of Von Mohl's scientific work. His energies were always ready to turn themselves to any part of his subject where facts seemed to need investigation, or the results of others to challenge re-examination or criticism. His papers are, in their way, models of "contributions to knowledge."

Von Mohl's first publication in 1827 was a prize thesis on the structure of climbing plants, in which he endeavoured to show that the stems have a dull kind of irritability, so that they bend towards any object which they touch. This explanation has given place to a better knowledge of the phenomena; but Mr. Darwin, to whom that service to science is largely due, bears witness to the *prima facie* probability of Von Mohl's view ('Journ. Linn. Soc.,' Bot. vol. ix, p. 10). His inaugural dissertation in 1828 (already alluded to) gave the first account of the true structure of the dots or "pores" frequently met with in the walls of cells ('Ueber die Poren des Pflanzenzellgewebes'). He showed that they were thinner portions of the cell-membrane.

In 1831 Von Mohl, as already mentioned, contributed to the 'Historia Naturalis Palmarum' of Von Martius an elaborate account in Latin of the structure of the stems and roots of palms, under the title "De Structura Palmarum." This was republished in German in his 'Vermischte Schriften' in 1845, and was translated for the Ray Society in 1849 by Prof. Henfrey. Von Mohl gave the final blow to the theory of the internal growth of monocotyledonous stems first propounded by Desfontaines, and upon which De Candolle had founded the division of vascular plants into Exogens and Endogens. In this memoir he appears to have first described the origin of ducts from rows of closed cells, a point which he further developed in the following year in a paper, "Ueber den Bau der porösen Gefässe.

The publication by Von Mohl in 1835 of his discovery of the multiplication of cells by division ('Ueber die Vermehrung der Pflanzenzellen durch Theilung') in *Cladophora glomerata* has been the starting-point of all subsequent investigations into the development of the tissues and organs of plants. It revealed, in fact, the precise mode by which vegetative *growth* is accomplished. Mirbel, in his memoir on the development of *Marchantia*, communicated to the Académie des Sciences in 1831 and 1832, but not published till 1836, had described the formation of pollen-grains by the quadripartite division of a mother-cell. This, however, though an extremely important observation, is not a case of growth, properly speaking, and does not affect Mohl's historical position in the matter. In 1838 Schleiden announced the multiplication of cells by the formation of new cells *in their interior* as a general law in the vegetable kingdom. He was supported by Nägeli. The views of Von Mohl, developed as they were by Meyen and Unger, eventually established themselves. In a paper on the structure of cork and bark, Von Mohl described the nature of the tissues which enter into their composition, and accounted for the diversity of their character in different plants, especially the exfoliation of layers of bark in such trees as the Plane.

In 1844 Von Mohl maintained, against the theory of Dupetit-Thouars, the dependence of the growth of Dicotyledons on the physiological activity of leaves. The same year he published his remarks on the structure of the vegetable cell, which for a long time immensely influenced the course of vegetable histology. He regarded the cell-well as generally composed of a primary external imperforate membrane, and a secondary one usually perforated with apertures. This he supposed to be lined by a third membrane, "Primordialschlauch," the primordial utricle of English writers. "This membrane forms a perfectly closed, cell-like, thin-walled vasicle, which in the fresh plant is closely applied to the inner wall of the cell, and therefore escapes observation; while in specimens which have been preserved in spirit it is contracted, and more or less detached from the wall."

Von Mohl's paper, "Ueber die Saftbewegungen im Inneren der Zellen," published in 1846 ('Bot. Zeit.,' p. 73), has been the starting-point of all modern views about the vegetable cell. He first described accurately the "opaque viscid fluid of a white colour, having granules intermingled with it, which fluid I call *protoplasm*." He observed the vacuolization of the protoplasm until it forms a mere network. He described the motion which takes place in the filament of the network, "or perhaps now first becomes visible," and he measured its rate. Schleiden gave the theory its finishing touch in the third edition of his 'Principles' (1849), by identifying Mohl's primordial utricle and circulating fluid.

In 1850 Von Mohl published a small work with the title 'Die Vegetabilische Zelle,' which weaves the results of a great deal of what he had written in scattered memoirs into a continuous whole. It was translated into English by Prof. Henfrey in 1852.

Von Mohl felt the greatest interest in improving the means of histological and anatomical research, and wrote several papers on the construction and use of optical instruments, and in 1846 published a book on micrography.

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

HISTOLOGY.[1]

II. The Cell.—1. *Spontaneous Movements of the Nucleolus.*—Brandt ('Arch. f. Mikr. Anat.,' Vol. X., p. 505) remarks that in the modern cell theory the function and nature of the nucleus have become obscure and little regarded. He himself describes some observations on the nucleolus (germinal spot) of an ovum from the ovary of *Blatta orientalis.* The ovarial eggs of this insect are cells with a granular protoplasma and a large transparent nucleus containing a nucleolus. The latter varies both in size, shape, and position in the nucleus, when different cells are compared. Continuous observation shows that these differerences depend upon amœboid movements of the nucleolus effecting both alteration of shape and locomotion. The movements are slow, but stimulated by heat. Bodies sometimes seen within the nucleus which are rather to be regarded as precipitates, and show no movements. These may be distinguished as pseudonuclei.

2. *Experimental Production of Giant-Cells from Colourless Blood-Corpuscles.*—Ernest Ziegler ('Centralblatt,' nos. 51 and 58, 1874), cut from mirror-glass plates of different sizes, some square and some oblong, ground off the edges carefully, and affixed to each with porcelain cement a fine cover-glass of the same size, so that there remained between the glass lamellæ an empty capillary space, accessible from all sides, with the exception of the corners. These plates were brought under the skin and periosteum of dogs and rabbits, or were introduced into one or other of the large cavities of the body. This was done under the impression that the colourless blood-corpuscles would penetrate into all the spaces, would wander under the cover-glass, and there, independently of the organism, be nourished by lymphatic

[1] The articles in this division are arranged under the following heads:— I. Text-books and Technical Methods. II. The Cell in General. III. Blood. IV. Epithelium. V. The Connective Tissues. VI. Muscle. VII. Nervous System. VIII. Organs of Sense. IX. Vascular System. X. Digestive and Respiratory Organs and Glands. XI. Skin and Hair. XII. Urinary and Sexual Apparatus.

The Editors will be glad to receive, for the purpose of making this record more complete, copies of separate memoirs or reprints from periodicals, which must otherwise often escape notice.

fluid, and undergo this or that metamorphosis. The author met with many failures, and recommends the following method. Small plates of glass must be used, 10 to 20 millimètres (0·04 to 0·08 inch) long and 10 millimètres (0·4 inch) broad. Large ones easily occasion profuse suppuration. The plates were generally left from ten to twenty-five days in the spot operated on. The best field for operating is the inner side of the thigh of not too old dogs. Rabbits gave no satisfactory results. After the plates were removed they were slightly washed, and at once placed in a 1 per cent. solution of perosmic acid, and allowed to remain there for two days. They were then placed in spirit with glycerine, then in pure glycerine.

The following were the results of sixty-five experiments. An in-wandering of colourless blood-corpuscles took place in all cases. The changes of the same in the first ten days varied according to the direction of the development. After several days, a flattening of the corpuscles and the formation of a cellular mosaic were often to be observed. After this time the author found:—

In the greater number of cases only retrogressive changes, but in some cases progressive processes showing different developmental directions, viz.:—

1 *a*. The Formation of a Reticular Tissue with Enclosed Epithelioid Cells and Rich Development of Giant Cells.—This is, without doubt, the most interesting result. The giant cells consist of finely granular protoplasm and certain numerous large oval nuclei and distinct nucleoli, sometimes with round sharp contours, at others provided with processes. It can be seen, in one and the same microscopical preparation, how they are developed from the colourless blood-corpuscles by increase of the protoplasm and simultaneous increase of the nucleus, till they reach the dimensions of the largest known giant-cells.

b. Development of Connective Tissues and Vessels.—Similar appearances to those of developing connective tissue were found. As the first stage in the development of the vessels there is clearly observed a network of peculiarly changed colourless blood-corpuscles ranged one on another, which increase considerably on the surface, and are firmly fixed on the edges, and gradually assume an epithelioid character. The author draws the following conclusions:—

c. Real giant-cells can develop from colourless corpuscles.

Under similar conditions, cytogenous connective tissue with epithelioid cells is formed.

These formations are to be regarded as analogous to certain forms of tubercle; or, in other words, tubercle with its giant-cells is an inflammation-focus in which the colourless corpuscles heaped up at any spot (probably intracanalicular—Rindfleisch, Schüppel), undergo a development. This, according to the author, is caused by imperfect nutrition of the cells, in so far as this is not sufficient to form new connective-tissue. According to this view, giant-cells are to be regarded as imperfect new cell-formations.

The formation of intercellular substance in reticular tissue is paracellular, arising anew by a cutting off from the sides of the cells. (Dr. STIRLING, in 'London Medical Record.')

III.—Blood.—1. *Purves on the Place where the White Blood-Corpuscles wander out of the Vessels.*—L. Purves ('Onderzoekingen gedaan in het Physiol. Labor.,' Utrecht, 1873, iii), to investigate the place where the white blood-corpuscles pass through the wall of the vessel in Cohnheim's experiment on inflammation, injected a solution of silver into the vessels of a frog prepared after the manner of Cohnheim. The colourless corpuscles, without exception, wander out between the boundaries of the epithelioid cells. They never pass through the substance or through the nucleus of an epithelioid cell. According to the author, the red-corpuscles only pass out by those channels which have been previously made for them by the colourless corpuscles. The author found no stomata of any kind on the epithelium of the vessels. (London Medical Record.)

2. *Influence of the Gaseous Contents on the Solubility of the Blood-Corpuscles.*—Landois ('Centralbatt,' No. 27, 1874) says that if different portions of the same blood be treated with carbonic acid, oxygen, and nitrous oxide, the red blood corpuscles exhibit great varieties with regard to their solubility. The corpuscles charged with carbonic acid are dissolved much sooner than the others. Certain reagents which are unable to dissolve blood charged with other gases, produce the "lake colour" at once in blood charged with carbonic acid. The reagents employed were salts of the bile-acids, very dilute solution of chloride of sodium, and serum of dog's blood for the blood of rabbits and guinea-pigs. Blood charged with nitrous oxide stands between that charged with carbonic acid and that charged with carbonic oxide. The blood-corpuscles of all sorts of blood become round before their solution, and show exceedingly fine points. Perhaps the condition of the hæmoglobin in the cells at the time may account for this.

3. *Formation of Fibrin from the Red Blood-Corpuscles.*—In a second part of the same paper, Landois describes the formation of fibrin as being dependent on the dissolved corpuscles. If a drop of defibrinated rabbit-blood be brought into a drop of frog's serum, the cells aggregate together, and become sticky on their surfaces. The cells soon become globular, and those cells lying towards the periphery allow the blood-colouring matter to pass out. This discolouring gradually extends towards the centre of the drop, and at last only a heap of stroma remains. The stroma-substance is very tough and viscid. At first the contours of the cells can be detected; and, when the stroma has been agitated to and fro, the cellular contours disappear, and viscous fibres and stripes are observed. Step by step the formation of fibrous masses from the dissolved mammalian cells can be observed. The author thinks this fibrin should be called "stroma-fibrin" in opposition to the ordinary fibrin or plasma-fibrin, which is formed without solution of the blood-corpuscles. The two kinds of fibrin may possibly be chemically distinguished from each other. In transfusion, if dissolution of the cells occur, then, of course, the formation of stroma-fibrin may take place. The coagulation occurs the sooner, the more serous the blood. Animals in a state of asphyxia, into whom heterogeneous blood was introduced, showed the most extensive coagulation.

IV. Epithelium.—1. *Cement-Substance of Epithelium.*—R. Thoma ('Centralblatt,' No. 2, 1875), in studying the physiological and pathological changes in the epithelium of the frog's tongue, discovered a method by which in the living animal an excretion of indigo in the cement-substance of the above organ, as well as in certain parts of the alveolar mucous membranes, could be produced. This cement-substance appears as a fine deep-blue coloured network, stretching regularly over the whole tongue, between the colourless epithelial cells, and lying somewhat below the level of the free epithelial surface.

The method is the following. A solution of pure sulphindigotate of soda is prepared by diluting, with an equal volume of distilled water, a saturated and filtered watery solution of indigo. This is injected, under a constant pressure, into the median abdominal vein of a frog, so that in the course of two to four hours from four to six cubic millimètres of the indigo solution are introduced into the body of a medium-sized *Rana temporaria* or *esculenta*. Simultaneously the tongue is irrigated by a 1·5 per cent. solution of chloride of sodium, in consequence of which pronounced widening of the vessels occurs, specially in the arteries, together with great acceleration in the blood-current ('London Medical Record,' Dec. 30, 1874). The microscope shows that the blood is coloured slightly blue. After a short time the connective tissue becomes blue, whilst the muscular fibres and epithelium show no obvious coloration. It is only after two or three hours that the cement-substance shows a deep blue coloration. (London Medical Record.)

2. *Goblet Cells of the Conjunctiva.*—Reich ('Centralblatt,' 1874, p. 737) believes certain cells in the conjunctiva resembling the "goblet cells" of other mucous surfaces, which have been regarded by Stieda as "unicellular mucous glands," and by Waldeyer also as normal secreting structures, to be pathological productions, resulting from the mucous transformation of epithelial cells, in consequence of catarrhal conditions. They vary much in number, but are seen chiefly in comparatively old people and in chronic catarrhal inflammations. In structure, too, they differ from the typical goblet cells, being globular or oval, sometimes with a terminal orifice produced by rupture, but never with the characteristic pedunculated form.

3. *Mucous Membrane of Urethra.*—Robin and Cadiat ('Journal de l'Anatomie,' Sept. and Oct., 1874) describe the epithelium, elastic fibres, and glands of the urethra, in the male and female.

V. The Connective Tissues.—1. *Structure of Tendons.*—Ranvier has re-examined this subject in consequence of the numerous criticisms which have been passed upon his views. His results are briefly as follows:

1. In the tendon of the tail of a young rat, or dogs, he finds the tendinous bundles separated by cells which have a dark granular body and an oval nucleus. Their shape is that of a tile applied by its concavity to a fibrous bundle, and presenting on its convex side crests and ridges, which really form casts of the surface of the adjacent bundles. In longitudinal sections they have the appearance of flat plates rolled round columns. In other animals the cells are thinner, but more solid, and have lateral prolongations, which make it difficult to determine their limits. In his first memoir Ranvier had taken for the lateral boundaries what are really two moulded crests (*crêtes d'empreinte*). Such ridges or crests have been described by Boll as the elastic stripe. The conclusion is that the form of the cells is determined by pressure during their development, and retained when they become old and rigid.

2. The femoral aponeurosis of the frog shows similar casts

or moulds of fibrous bundles in the substance of a cell or nucleus.

3. The sesamoid cartilage in the Achilles tendon of the frog contains elements which are not really cartilage-cells, containing beside a large oval nucleus a stellate granular body, stained brown by iodine.

4. The ossified tendons of birds are true bone, but the fundamental bone-substance is chiefly represented by altered tendinous bundles, which here play the part of Sharpey's fibres. It may hence be called bone almost exclusively made up of Sharpey's fibres.

5. The tendinous bundles in all periods of development take their rise in a mass of cartilage, and terminate in a primitive muscular bundle. The bundles may be seen passing into the intercellular substance of the cartilage, and the tendon-cells corresponding to the rows of cartilage-cells, while transitional forms of cells are seen. Thus are explained both the occurrence of cartilaginoid cells in tendon, and the tendency of this tissue to ossify. ('Archives de Physiologie,' 1874, p. 181.)

2. *Structure of Tendon.*—Goff and Ramonat ('Journal de l'Anatomie,' 1875, p. 16) publish a paper on the cells of tendon, in which they arrive at the following conclusions:—(1) The cells of tendon are of a laminated nature (*nature lamineuse*), as shown by reagents. (2) These cells arise from free nuclei which become surrounded by a fusiform cellular body, at the extremities of which are formed the laminated fibres. (3) These elements adapt themselves so as to fill the whole interfascicular space. (4) The cells remain fusiform in some tendons, and in all the tendons of some animals. They are generally small in the large tendons of adult mammalia.

3. *Adenoid Tissue in the Larynx.*—Heitler ('Stricker's Medin. Jahrbücher,' 1874, p. 374) states that adenoid substance constantly occurs in the normal mucous membrane of the human larynx, and especially in the following parts: —The arytæno-epiglottidean folds near the spot where the pavement epithelium makes a transition to the cylindrical; the surface covering the arytenoid cartilages themselves, and especially the upper part of this, overlying the cartilages of Santorini; the membrane covering the most anterior division of the ventricles of Morgagni, and especially the folds of that part which form a blind sac directed upwards. Beside these masses of adenoid substance, Heitler describes a diffuse infiltration with small cells, extremely variable in

number, but in some places occupying nearly the whole thickness of the mucous membrane.

Process of Ossification.—A. von Brünn ('Reichert's Archiv,' 1874, p. 1; 'Centralblatt,' 1874, p. 727) gives the following summary of his conclusions on ossification from cartilage.

(1) The cartilage-cells multiply and arrange themselves so as to form in the diaphysial part of the epiphysis—cartilage bony row; in the epiphysial portion of the same and in the short bones, groups; both corresponding in direction to the medullary masses which afterwards find their way in. They increase in size towards the limit of bone, and thus enlarge the cavities in which they lie. The differentiation of the fundamental substance follows a different direction according as the bone is embryonic and unfit for use or is actually to be used. In the former case the cartilage-capsule is very conspicuous around the enlarged cells, though it afterwards vanishes near the limit of bone. In the latter case the basic substance only remains hyaline where it immediately surrounds the rows of cartilage-cells and the capsules; that which lies between the columns of hyaline substance becomes converted into an elastic fibrous tissue.

(2) The cartilage-cells remain in the medullary spaces as medullary cells, where they become converted into osteoblasts, and as such form bone. The greater part are converted into bone substance, but a certain number remain as bone-corpuscles. The canaliculi are formed by absorption.

VII. Nervous System.—1. *Course of the Fibres in the Posterior Commissure of the Brain.*—In Siebold and Kölliker's 'Zeitschrift für Wissenschaftliche Zoologie,' vol. xxiv, Heft 3 (September 16, 1874), Dr. Paulowsky records the result of his investigations into the structure of the so-called posterior commissure of the brain. This body has been variously described; most authors, however, believing that its fibres run transversely between the two thalami optici, thus serving to connect the two hemispheres of the brain. According to Arnold, the commissure really consists of two factors, one of which belongs to the "Schleifenregion," the other to the hemispheres. [The "Schleife" answers to the *lemniscus* of Reil. The first factor probably answers to the commissure of Wernekinck.—*Rep.*] Luys has remarked a crossing of the nerve-fibres in the commissure. Meynert describes this structure as the crossing place of the anterior and posterior crura of the corpora quadrigemina, which, after crossing, pass over into the tegmentum ("Haube") of the crus cerebri.

Besides this it is in communication with the pineal gland and the 'ganglion habenulæ.'

Dr. Paulowsky made his observations on preparations from man, sheep, dogs, and rabbits. He arrives at the following conclusions :

1. The so-called posterior commisure consists of coarse fibres running down from the brain to the tegmentum of the crus cerebri.

2. These fibres have a four-fold origin—

(α) In the pineal gland ;

(β) In the frontal lobe of the brain (through the anterior peduncle of the thalamus);

(γ) In the temporal lobe and in the fissure of Sylvius (through the inferior peduncle); and

(δ) Probably in the thalamus itself.

3. In the tegmentum one portion of the bundle of fibres runs with the "Schleife," while another lies to the inner side of the same.

4. Commissural, or bridge-like fibres, do not exist at all in the posterior commissure.

5. Therefore the term "commissura posterior" is an incorrect one, and it would be more advisable to call this region of the brain the crossed tract of the tegmentum—"tractus cruciatus tegmenti." (*Medical Record.*)

2. *Course of Fibres in the Spinal Cord.*—Schiefferdecker ('Arch. für Mik. Anat., vol. x, p. 471, plates 32, 33, 34) has studied this subject by horizontal and longitudinal sections of the spinal cord of a dog in the lumbar enlargement at the level of the 1st and 2nd sacral nerves. The cord was hardened four weeks in Müller's fluid, then preserved in alcohol. The sections were made with a small microtome, and tinted with chloride of gold (longitudinal sections), or chloride of palladium (transverse sections), and finally mounted in Canada balsam. The strength of the tinting solutions was about 1 to 10,000. In one instance at least, the direct prolongation of axial processes of a ganglionic cell into the anterior roots of a spinal nerve was observed.

The general principle of distribution of the fibres in the cord is according to the author, simply that of the utmost possible mutual connection, as shown in the following arrangement:

(1) Passage of fibres from the white into the gray substance occurs in three modes :—(*a*) Fibres starting from the same point enter the gray substance at different levels ; (*b*) Fibres coursing through different portions of the white substance may enter the gray substance at the same point ; (*c*) Fibres

which belong to the same vertical bundles, and which bend round into the gray substance at the same level, may diverge in their passage through the white substance, so as to enter the gray at different points of the same horizontal plane.

(2) Intermingling of fibres takes place by the diversity of their course through the gray substance, viz., either (*a*) by the formation of simple networks (without ganglion-cells); (*b*), or by strands which traverse considerable portions of the cord, either commissurally so as to connect the two halves of the cord, or vertically so as to connect portions of the cord situated at different levels.

(3) Special arrangements which probably serve in part, at least, to connect nervous fibres of different function are seen in the ganglionic cells with their close networks between them. One of these groups of cells, if it could be taken out entire with its nervous attachments, would be like a rolled-up hedgehog with its spines.

(4) Finally, must be enumerated the mode in which the fibres of the posterior roots enter the cord, with their decussations and their further horizontal and vertical course.

3. *Distinction of two Nerve-centres in the Brain.*—Betz ('Centralblatt,' 1874, p. 578) seeks to distinguish in the human brain two limited regions, which he regards as special nervous centres. One of them is thus indicated. The fissure of Rolando divides the cerebral surface into two parts, the anterior of which is distinguished by the abundance of large pyramidal ganglionic cells, the posterior by the predominance of the nuclear layers. Of this anterior half the posterior portion forms a region, having certain peculiarities. The region is limited by the whole of the anterior central convolution and the upper end of the posterior central convolution, and extends to the inner surface of the hemispheres, where it forms a constantly present clearly defined lobe.

Again, the posterior portion of the half of the hemisphere, lying behind the fissure of Rolando, forms an equally distinct but larger region. This extends through the cuneus, the hinder parts of the lobus lingualis and lobus fusiformis along the whole outer extremity of the occipital lobe, and also into the transitional convolutions which are found in the external occipital fissure.

The former of the special regions thus indicated contains cell-forms of a very peculiar kind, till now undescribed. They are the largest pyramidal cells seen anywhere in the nerve-centres, and might be called "giant pyramids," being ·05 to ·06 m.m. broad, and ·04 to ·012 m.m. long. Each possesses two principal processes, and 7 to 15 secondary protoplasmic processes, which break up into still smaller ones. One of the principal processes is at its commencement thick and tapers off in its course to the surface of the cortex, giving off at the same time, lateral twigs. The other process is, on the contrary, thin at its commencement, starts from the nucleus and passes direct into the axis-cylinder, which after a short course enlarges and becomes invested with a white sheath, and is therefore undoubtedly continued in the form of a nerve. These giant-cells are chiefly situated in the fourth cortical layer, but not in a continuous sheet, forming on the other hand, groups of one, two, three, or more, which are ·3 to ·7 m.m. distant from one another. These groups are found more sparingly in the brains of quite young individuals, and in old persons the cells have a peculiar yellow nucleus, not tinted by carmine. They are more numerous in the right hemisphere than in the left. The white substance in the same regions contains an unusual number of thick white axis-cylinders, which in their arrangement and thickness resemble the axis-cylinders of the anterior cornua of the spinal cord.

These cells are found in the corresponding situations in every human brain, as well as in various apes. In the dog they are somewhat smaller, but still the largest in the nerve-centres. They are found in this animal only in the lobe bordering the *sulcus cruciatus,* which has become known through the physiological researches of Fritsche and Hitzig; and in the convolution adjacent to this lobe. In man and the higher apes, they are found in a lobe not clearly recognised by anatomists which Betz calls *lobulus paracentralis*, being found on the inner side and in front of the fissure of Rolando, on the inner surface of the hemisphere. It is separated in front by a fissure from the first frontal convolution; behind by a fissure from the lobulus quadratus, and is bounded below by the gyrus fornicatus. This lobe Betz believes to be identical with that described above from the dog, though the latter is situated on the outer and anterior surface. In both cases he believes it to constitute a "motor centre."

The posterior centre is larger than that just described, but varies in size, according to the development of the external occipital fissure and the transitional convolutions. It is distinguished by the presence of large cells (already described by Meynert) which have few protoplasmic processes. Those of the processes which run towards the internal surface, never reach it, but take a horizontal course and effect a communication of the cells with one another. The processes which run in the opposite direction are less considerable, These cells, like those of the anterior centre, are arranged in groups of two or three. This centre Betz believes to be a "sensory centre." The two parts of the hemisphere would then be analogous to the two parts of grey matter of the spinal cord; all in front of the fissure of Rolando corresponding to the anterior cornua; the part behind this fissure (with the temporal lobe) to the posterior cornua. This parallel is further developed.

4. *Minute Anatomy of the Cerebellum.*—Golgi (abstract in 'Centralblatt,' 1874, p. 694) has obtained remarkable results by the application of a new method to the investigation of the cerebellum. The molecular (grey or external) layer of the cortex of the cerebellum contains a system of nerve-fibres not yet properly appreciated in its anatomical connections or its importance, which must be regarded as prolongations of those which exist in the granule-layer (rusty brown or internal layer). They exist in every part of the molecular layer, but more conspicuously in its inner half, or even its inner third. The stouter fibres belonging to this system run parallel to one another, and for a considerable distance, some being traceable round the whole of one cerebellar convolution. Other characteristics of this system of fibres are —(1) Branches which during the whole course of the fibres are given off towards the centre and towards the periphery. (2) The mode of giving off these fibres, which leave the trunk either at right angles or almost at right angles. (3) The main fibres are mutually connected, either by short intermediate branches or directly. (4) The course of the fibres prolonged and complicated by extraordinary loops, twists, spirals, and knots. This is more especially the case in the inner portion of the grey or molecular layer.

A dense mass of nerve-fibres exists at the boundary of the molecular and granular layer, some single, some in bundles, which pass into the molecular layer and then enter into communication either with the fibres of that layer or with the small ganglionic cells which are found there. These fibres all give off branches, and thus form an extremely complicated system. The number of such ganglionic cells contained in the grey or molecular layer Golgi finds to be very great. They are scattered through this layer from the large ganglionic cells of Purkinje to close under the pia mater. Their size is about 6—12 mm. diameter, their shape irregular; each is furnished with four or five protoplasmic processes, and one so-called axis-cylinder process, which resembles the axis-cylinder process of the pyramidal cells of the cerebral cortex, breaking up into a number of minute nerve-fibres.

The well-known large ganglionic cells discovered by Purkinje are described by Golgi as having ramifying protoplasmic processes of extraordinary complexity, the ultimate destination of which he was unable to trace. The axis-cylinder process passes through the granule-layer into the nerve-fibre tract, and there gives off numerous fine processes, of which some bend back into the molecular or outer layer of the cortex. The elements of the granule-layer are mostly small ganglionic cells possessing an axis-cylinder process and numerous branched protoplasmic processes. They are usually one half or one third the size of Purkinje's cells, that is, twenty to sixty mm. in diameter, but some attain almost to the dimensions of those cells. The fibres which pass into the granule-layer and bend outwards divide and ramify there in a very complicated manner, some of the minute fibres entering into connection with the small ganglion-cells of that layer. The nerve-fibres of this layer also, like those of the other layer, form loops, twists and knots, so that a system of great perplexity results.

5. *Variations in the Structure of the Spinal Cord.*—Flechsig ('Centralblatt,' 1874, p. 561) describes variations in the spinal cords of infants born at full time, especially with regard to the continuation of the pyramids into the columns of the cord.

6. *Development of Nerves.*—See 'Observations sur le développement des nerfs périphériques chez les larves de Batraciens et de Salamandres,' par Ch. Rouget ('Comptes Rendus Acad. des Sciences,' 1874, p. 306 and p. 448).

VIII. Organs of Sense.—1. *Structure of the Olfactory Mucous Membrane.*—Cisoff ('Centralblatt,' 1874, p. 689) has reinvestigated this structure, in order to compare the original statements of Max Schultze with the conflicting results of Exner (see 'Quart. Journ. Mic. Sci.,' 1871, vol. xi, n. s., p. 300), and believes the differences to depend partly on the different methods employed. Exner described a sub-epithelial network of nerve-tissue, which was connected on the one hand with twigs of the olfactory nerve, on the other hand with both the epithelial cells and the "olfactory cells" of the surface. Cisoff affirms that the apparent connection of this network or the sub-epithelial tissue with nerve-fibres is illusory, and is only seen in osmic acid preparations. In sections of gold preparations the nerve-fibres are clearly seen passing through the sub-epithelial tissue into the epithelial layer, forming no connections in the former; and the same thing is seen when the epithelium is removed by careful maceration. On the other hand, the epithelial cells he finds to be connected with large stellate cells of the sub-epithelial layer. (The sub-epithelial tissue is accordingly not nervous, as asserted by Exner.)

With regard to the connection of the olfactory cells with fibres of the olfactory nerve, Cisoff was able to demonstrate this in a few well-marked instances, and even fine nerve bundles were seen thus connected with "olfactory cells." The latter cells were never seen in connection with the sub-epithelial tissue. The central process of the olfactory cell has, as described by Max Schultze, a striking resemblance to a varicose nerve-fibre. The general conclusion is that Schultze's description is in the main correct, though somewhat diagrammatic. The observations were made on the frog and the rabbit. The chief reagents used were chloride of gold, diluted Müller's fluid, and as a staining material hæmatoxylin. Paschutin ('Leipzig Physiolog. Arbeiten,' 1873, p. 41) had equally denied the nervous character of Exner's sub-epithelial network, while confirming its connection with the epithelial cells. Both observers agree in maintaining Schultze's distinction of epithelial and olfactory cells.

2. *Termination of the Gustatory Nerve.*—E. Sertoli ('Gazetta Medico-Veterinaria,' anno iv, abstract in 'Centralblatt für die Medicin. Wissenschaften,' no. 55, 1874) investigated the papilla foliata of the tongue of the horse. For the investigation, the author employed a very interesting modification of the gold method. Small pieces of fresh tissue were placed in a relatively large quantity of gold solution ($\frac{1}{4}$ to $\frac{1}{3}$ per cent.) and allowed to remain therein for eighteen or twenty-four hours, then washed out with water, and placed for twenty-four to forty-eight hours in a 2 per cent. solution of bichromate of potash. They were then washed out with water and placed in absolute alcohol, in which they were completely hardened, and in which the colouring already begun in the bichromate of potash became perfect. The colouring can be accelerated by exposing the preparation in bichromate of potash to a temperature of 30° Cent. (86° Fahr.). The papilla foliata is very richly supplied with nerves. In the subepithelial connective-tissue the nerves form a very dense network, to end in the two following ways: (1) in the gustatory bulbs, which are present in extraordinarily large numbers in the folds and furrows of the papilla foliata; (2) in an intra-epithelial network of fine

non-medullated nerve-fibres, intensely coloured by chloride of gold. In addition to this network, stellate bodies coloured dark violet by chloride of gold lie among the pavement-epithelium, the bodies being similar to those described by Langerhans from the human epidermis. Sertoli is inclined to regard them as non-nervous. As this intra-epithelial nervous network lies deeply imbedded and protected in the furrows of the papilla foliata, it cannot, according to Sertoli, be regarded as an anatomical substratum of tactile sensibility, and he also claims it as a gustatory organ, as the form of termination of the specific sensory nerves of the tongue. In fact, this same intra-epithelial nerve-ending, which often penetrates to the most superficial layers of the epithelium, occurs quite commonly in the papillæ fungiformes of the horse's tongue. These papillæ are distributed in great numbers and with great regularity over the whole dorsum of the tongue, and it is very tempting to regard this form of ending as the anatomical condition of the gustatory sense distributed over the whole surface of the tongue.

The conclusion of the paper is occupied with the consideration of the minute anatomy of the gustatory discs (which are tinged of a very characteristic dark colour by chloride of gold. (*London Medical Record.*)

IX. Vascular System.—1. *Contractile Coat of Blood-vessels.*—Rouget ('Comptes Rendus,' Aug. 31st, 1874) describes cells with ramified processes from the outer coat of vessels. They are truly contractile, and arise, he thinks, from migratory amœboid cells.

2. *Lymphatics of the Liver.*—Von Wittich ('Centralblatt für die Medicinischen Wissenschaften,' No. 58, 1874), like Sikorski, has been able in the living rabbit to inject from the trachea an exceedingly irregular but narrow-meshed network lying partly in the pleura, partly in the subpleural tissue, and partly in the interstitial pulmonary tissue, and accompanying the blood-vessels; the author regards this network as consisting of lymphatics. In the freshly killed animal he succeeded in injecting, not only this network, but also the intercostal spaces and even the external thoracic muscles when artificial respiration was performed.

If a rabbit be killed by bleeding, and, whilst artificial movement of the thorax is kept up, there be injected into the trachea, under moderate pressure, a concentrated solution of sulphindigotate of soda, one is struck with the quantity of fluid employed, and with the fact that the whole animal becomes of an intensely blue colour. The skin, the coverings of the eye, the tendons, the muscles, and the abdominal viscera, all become more or less blue, just as by injection into the blood. In only two places has Von Wittich been able to follow exactly the blue-coloured channels, viz. in the choroid and in the liver. In both organs the blood-vessels were almost completely empty, or only partially filled with blood. The blue colour of the choroid arises from a blue layer lying around the vessels (Morano's lymph-sheath of the choroidal vessels); in the liver a fine injected network surrounds the portal vein and the branches of the hepatic vein, from which exceedingly fine, delicate, blue injected processes penetrate into the hepatic lobules between the blood-capillaries and the hepatic cells. Strongly injected vessels, evident to the naked eye, pass from the hilus, run parallel to the large vessels and the bile-ducts, and surround these, their finer branches passing towards the branches of the portal vein, but the author observed no direct communication between these and the perivascular network. These vessels are not to be confounded with the blood- or bile-capillaries, and Von Wittich can only recognise them as lymph-capillaries. Further particulars as to the method employed are promised. (*London Medical Record.*)

X. **Digestive Organs.**—*Minute Anatomy of the Alimentary Canal.*—Mr. Herbert Watney ('Proc. Roy. Soc.,' No. 152, 1874) has arrived at the following results:

1. *Connective-tissue Corpuscles amongst the Epithelium.*—In specimens hardened in chromic acid and alcohol and stained in hæmatoxylin, structures are constantly seen among the columnar epithelium of the intestinal tract in many animals (as monkey, sheep, cat, dog, rat, rabbit) which belong to the connective tissue. These are:—(1) a delicate reticulum, which is continuous with that formed by the most superficial layer of connective-tissue corpuscles (the basement membrane); (2) round nucleated cells, exactly similar to those of the mucosa.

This is the case at the pyloric end of the stomach, or the villi, over Peyer's patches, and in Lieberkühn's glands.

2. The lining endothelium of the lymph-vessels of the mucosa is in anatomical continuity with the reticulum of nucleated cells (connective-tissue stroma); so that it may be said the endothelial cells of the lymphatic vessel are only transformed connective-tissue corpuscles.

3. In animals killed during the absorption of fat (cream) the fat can be seen in preparations stained by osmic acid as small black particles:—(1st) arranged in lines between or around the epithelial cells; (2ndly) in the basement membrane; (3rdly) as has been noticed by many previous ob-

servers, in the connective-tissue stroma of the villus, whence it can be traced into the lymph-vessel. This indicates that the fat is absorbed by the processes of the connective-tissue which exist between the epithelial cells, and thence finds its way by the connective-tissue stroma to the lymph-vessel.

4. The reticulum of nucleated cells of the mucosa forms a special sheath to the vessels and unstriped muscular tissue.

In the villi the muscular bundles, having approached the apex, terminate, the connective-tissue which forms their sheath being continuous with the corpuscles forming the basement membrane.

In the mucosa of the colon of the rabbit the slender muscle-bands divide into single muscle-fibres, on which the common sheath is continued. This sheath becomes often connected with peculiar large, oval, nucleated cells lying close under the epithelium.

Observations were also made on the state of the lingual glands in rest and secretion.

XI. Skin, Hair, &c.—1. *Conglomerate Glands of the Skin in Man.*—Heynold gives the results of his examinations of the various conglomerate glands in man ('Virchow's Archiv,' part 1, 1874). After distinguishing the efferent duct from the coil itself, in common with other authors, he quotes Kölliker, to the effect that the commencement of the former is invariably narrower than the lumen in the coil itself, and continues so to its entrance into the Malpighian layer, where it dilates to about double the size, and, retaining this breadth, it traverses the epidermis. In the corium the sweat-glands always have a distinct cavity, and an external investment of connective tissue, with elongated nuclei, without smooth muscular fibres, and an epithelium of at least two layers of polygonal nucleated cells without pigment-granules, &c. In order to examine the condition of the excretory duct, Heynold used pieces of skin hardened in either two per cent. of bichromate of ammonia or in Müller's solution and afterwards in alcohol, and partly in one half per cent. of osmic acid. The latter liquid was allowed to act for twenty-four to thirty-six hours, after which the pieces were placed in absolute alcohol. The following are the result of his investigations:

1. All secreting canals of the conglomerate glands are more or less provided with muscles.

2. All secreting canals possess (towards the lumen) a sharply demarcated cylinder-epithelium without cuticle.

3. All excretory ducts are devoid of smooth muscular fibres, and are invested with a cuboid epithelium of several strata, the innermost of which has a distinct cuticle.

As regards the glands of the axilla, the author arrived at the following results.

1. There exists in the axilla two different kinds of glands (axillary glands and sweat-glands).

2. The axillary glands are very large, and show a very strongly developed muscularity.

3. The epithelium of the axillary glands consists of one layer, is cuboid, shows a very broad cuticle, and is coloured brown by osmic acid.

4. The excretory ducts of the axillary glands have an epithelium of sometimes one or more layers, but the innermost stratum always possesses a cuticle. In the first case they sometimes possess muscles and are very wide ; in the second case they are mostly narrow and without muscles.—*London Medical Record.*

2. *Dental System of the Amphibia.*—We can only mention Hertwig's very elaborate memoir on this subject ('Archiv für Mikr. Anat.,' vol. xi, supplement, pp. 208, five plates), in which he discusses the histology and development of the teeth, and the skeleton of the mouth in relation to embryology and finally in its bearings on the theory of the vertebrate skull. With reference to the latter point, Hertwig agrees with Huxley in his rejection of the old *vertebral theory*, but believes the true solution to be that of Gegenbaur, as given in his memoir on the Selachian fishes, and thus formulates his own views. The skull of vertebrates originates from the most anterior division of the axial skeleton by fusion of a large number of *metamera*, at a time when the axial skeleton shows no ossification. The inferior arches pertaining to the individual *metamera* form the visceral skeleton. In the Selachii we have the immature developmental stage of the skull, which is only transitory in the higher animals, viz., a complete cartilaginous capsule, which is the primordial cranium. In Ganoid and Telcostean fishes, in Dipneusta (Lepidosiren, Ceratodus) Amphibia, and in all amniotic vertebrates, the skull is variously altered by ossification.

The cranial bones originate in two ways. A certain portion of them are derived from the dermal skeleton, that is, from structures which, in the progenitors of these vertebrate classes named above, formed a continuous investment of scales or plates over the whole surface. By various processes these become changed into bony plates, and some of them becoming more deeply situated, become attached to the primordial cranium, so that a portion of external skeleton becomes internal skeleton. The bones thus derived are the secondary or investing bones of the primordial cranium or the membrane bones.

The remaining bones of the cranium, the so-called primary or cartilage bones are ossified portions of the primordial cranium. In the amniotic vertebrates only small portions of the primordial cranium remain, partly because of ossification, partly because the investing bones cause the absorption of and replace those portions of the primordial cranium which they cover.

XII. Sexual Organs.—1. *Development of Spermatozoa.*—La Valette St. George ('Arch. f. Mikr. Anat.,' vol. x, p. 495, plate xxxv) continues his researches on the subject, treating specially of certain arthropoda and mollusca, referring also to the observations of Balbiani, Metschnikow and Bütschli.

2. *Changes of the Graafian Follicles.* — Slaviansky ('Archives de Physiologie,' Nos. 2 and 3, 1875) gives the result of some elaborate researches on the development and maturation of the Graafian follicles, which he believes to be quite independent of menstruation.

3. *Accessory Glands of the Sexual Organs.*—Langerhans ('Virchow's Archiv,' lxi, p. 208) discusses the histology of the prostate, vasa deferentia, and vesiculæ seminales.

PROCEEDINGS OF SOCIETIES.

Medical Microscopical Society.

At the Meeting of this Society on Friday, Feb. 19, Dr. J. F. Payne, the President, in the chair—the minutes of the previous meeting were read and confirmed.

Dr. D. B. Woodman read a paper "On a Natural Method of Mounting certain Microscopic Specimens," which consists of putting up urinary deposits, sputa, &c., in their mother liquor, with or without the addition of a few drops of a concentrated solution of crystallized carbolic acid, and then thoroughly cementing round the edge of the cover-glass with some good cement. Dr. Woodman had specimens which had been preserved by this method for fourteen years without change. He also stated that epithelial casts could be kept thus for some *months*, though they ultimately became useless. He did not think that asphalt varnish deserved all the abuse that was levelled at it.

D . Pritchard objected to asphalt unless prepared as used by Mr. Miller, viz. dried and redissolved in dammar varnish.

Mr. T. Durham and Mr. Groves thought a mixture of asphalt and gold size in equal proportions formed a very tough cement.

The President preferred Frankfort cement.

Mr. Needham then described a method he had adopted for marking specimens in hardening solutions by the use of coloured glass beads—black representing No. 1; red, No. 5; green, No. 10 &c., so that by a combination of these any number could be produced. A numbered record of all the preparations was kept in a note-book, so that any specimen could be found with ease.

Mr. F. H. Ward then exhibited and described a Swiss gauge, which he used for measuring the thickness of covering-glass.

The meeting terminated with the exhibition of a number of specimens.

Dublin Microscopical Club.

19*th November*, 1874.

Heterostegina Australis and Antenna of Miris murarius, exhibited.—Dr. Macalister exhibited a section of *Heterostegina Australis* and drew attention to its structure, showing the peculiar cameration of that genus, and the characteristic stolon canals. He also showed the antennæ of the heteropterous insect *Miris murarius* (Fam. *Capsidæ*), presenting the ten-jointed elliptical extremities characteristic of the species.

Navicula Kittoniana, n.s. O'M., *and new Cyclotella, C. papillosa*, n.s. O'M., *exhibited.*—Rev. E. O'Meara exhibited a form of *Navicula* found by him in a gathering made lately at Lough Neagh, near Lurgan, and which he considered undescribed. The following is a description:—L. of Fr., ·0080″; greatest br. of the valve on S.V., ·0008″; slightly inflexed at the middle, where the br. is ·00075″; ends abruptly rounded; central nodule large and prominent; median line well defined, slightly undulate; at either side of the median line is a broad unstriate space, considerably expanded around the central nodule; transverse striæ linear, fine, parallel; longitudinal striæ easily detected. The species he proposed to name *Navicula Kittoniana.*—Mr. O'Meara also showed from the same gathering a form of Cyclotella which he considerd not described, at least satisfactorily:—Marginal striæ on the valve very fine; central portion unstriate, and occupied by a circlet of papillæ usually 5—6 in number. He considered it not unlikely that this form may be identical with one of the many varieties described by Ehrenberg, as *Discoplea atmospherica*, from Nepal ('Micr.,' xxxii, v, f. 4, also, from 'Fagun Egypt,' t. xxxii, i, f. 3), but as the figures differ so widely from one another, even if there were no doubt of the identity, a distinct name is required to mark the peculiar character of the species, which he (Mr. O'Meara) proposed to designate *Cyclotella papillosa.*

Muscle Fibre and Fibre-cells exhibited.—Mr. B. Wills Richardson exhibited two mountings in glycerine gum of organic muscle fibres and fibre-cells—one from the stomach of the ox, and the other similar structure from the human stomach at birth. The fibres and cells were stained with the bluish-grey which Mr. Richardson had described in the 'Quarterly Journal of Micr. Sc.' for July, 1874.

Cyathus crucibulum, Hoff., *exhibited.*—Dr. Moore showed examples of *Cyathus crucibulum*, Hoff. = *Nidularia crucibulum*, Persoon,—the cups filled with sporangia attached by their elastic pedicels forming a very pretty low-power object.

Xenodochus carbonarius.—Mr. Greenwood Pim, jun., showed examples of the rare *Xenodochus carbonarius* from leaves of *Sanguisorba*; from the neighbourhood of Liverpool the moniliform chains formed by the plant he had detached and mounted, forming an exceedingly pretty object.

Structure of Spines of Stomopneustes variolaris, Lamk.—Mr. Mackintosh presented transverse sections of the spines of the foregoing species. The structure of the spines of the genus *Stomopneustes* somewhat resembles that of *Colobocentrotus* already described in the Proceedings of the Club. Centrally it consists of very fine reticular tissue with rounded interspaces; extending outwards from this to the circumference is a quantity of network with irregular polygonal meshes, containing at intervals pillars of solid matter very much larger than, but somewhat of the same shape as, those in *Heterocentrotus* (*Acrocladia*); extending from the central reticulation to the first ring of pillars are a number of solid radiating bars, like those which extend from centre to circumference in *Heterocentrotus*.

Heterophrys marina (?), Hertwig et Lesser, *exhibited, from fresh water; and on the proposed genus Ouramœba*, Leidy.—Mr. Archer showed an example, treated with Beales' carmine fluid, of a rhizopod which was seemingly indistinguishable from Hertwig and Lesser's form above named ('Schultze's Archiv für mikr. Anatomie,' vol. x, p. 213), which he had just met with in a gathering made at Callery Bog. Leaving out of view the chlorophyll granules, generally speaking a somewhat inconstant characteristic in rhizopodous forms, there seems not much—except smaller dimensions—to distinguish this form from *H. myriopoda*, Archer. Thus there can be little doubt but that *Acanthocystis turfacea*, Carter, occurs colourless, and probably in that condition forms Greeff's *Acanthocystis pallida* ('Schultze's Archiv für mikr. Anatomie,' Bd. v, p. 489, t. xxvii, f. 19). On the other hand, *Raphidiophrys viridis*, Archer, *appears* to be always green. The present example well showed the *nucleus*, to adopt Hertwig's interpretation of this body, which has strongly imbibed the carmine dye. But what Mr. Archer especially wished to direct attention to was that the whole of the characteristic fimbriated margin had disappeared under the treatment, showing that these marginal processes forming the fringe-like border between the pseudopodia, and through which these latter, proceeding from the central body, issued, were not *spines* (Stacheln) but soft substance, some protoplasmic modification. The true spines of *Acanthocystis Pertyana*, Archer, some examples of which occurred *on the same slide*, did not so suffer or become altered under the self-same treatment. Hertwig and Lesser speak in *H. marina* of the outer region as a "skeleton," and the *fringe* as "spines." Would not that imply that the structure is hard and siliceous (or, as might be in other cases, calcareous)? In *H. Fockii*, Archer, there are no marginal fringe-like (quasi-spines) at all, but only an irregularly bounded, striated ("streaky"), perhaps varying in density, tenacious kind of fabric ("Gefüge," Hertwig), disappearing under reagents. On the whole, if the form now drawn attention to be identical with *H. marina*, Hertwig, then that, as a species distinct from *H. myriopoda*, would fall to the ground, though *à priori* the difference of habitat is in favour of their being distinct.—Had time permitted, Mr. Archer would have drawn attention to a dyed speci men, on the same slide, of the form he had provisionally thought to be equivalent to *Plagiophrys spherica*, Clap. et Lachman. This was precisely identical with the figure he had given in 'Quart. Jrn. Micr. Sc.' (vol. xi, p. 146, pl. vii, fig. 13), showing, as there depicted, the ellipsoidal nucleus, &c. This form, however, seems to be regarded by Hertwig and Lesser as a distinct species of *Plagiophrys*.—Mr. Archer, however, though unable to show the Plagiophrys example, took the opportunity to mention, in reference to Professor Leidy's remarks in a paper on Rhizopods, read by him before the Philadelphia Academy, of which he had seen only the brief abstract in the 'Monthly Microscopical Journal,' Nov., 1874, p. 251, that he could not as yet concur with that observer as to the validity of the proposed genus *Ouramœba*. *Amœba villosa*, Wall., Mr. Archer had shown at a meeting of the Club on 15th Feb., 1866, and again on 24th Feb., 1870 ('Quart. Jrn. Micr. Sc.,' vol. x, n.s., p. 305), whilst at a very recent meeting Dr. Barker had had a specimen, each in just the same condition (but which, before being exhibited, got lost!), all, doubtless, quite the same as that drawn attention to by Dr. Leidy, that is, showing *Amœba plus* a tuft or bunch of slender, elongate, linear, simple processes issuing from the posterior region, not at all employed in progression; these, Mr. Archer thought, *are* capable of retraction. Dr. Leidy speaks of "several forms" referable to his proposed genus, *Ouramœba;* without figures they would not be very intelligible. He suggests the possibility that some of the forms he refers to may be the same as *Plagiophrys*, Claparède. This genus is *quite* distinct indeed from the tufted states of Amœba Mr. Archer had previously drawn attention to. Plagiophrys has (as the present example would show) a distinct, almost membranous, even glossy tegument. Dr. Leidy seems to suggest, too, that *Pamphagus*, Bailey, might have been one of the forms he had before him; that is, perhaps, possible, for in *Pamphagus* it does not seem feasible to demonstrate a truly distinct outward coat or membrane; still the boundary is quite defined, and the broadly pyriform figure but little changeable, whilst very rigid and angular bodies, when incepted, even when the organism is crammed to excess, do not stick out through or lacerate the tegument, if, indeed, the external boundary can be so denominated. Still, it may turn out that *Pamphagus mutabilis*, Bailey, and the species of *Plagiophrys* are in reality all congeneric forms, but specifically the former is unmistakably and strongly distinct from any referred to the latter, and not any of them are for a moment comparable (except, indeed, in a very distant way) to the Amœbæ with the linear (Mr. Archer thought temporary) appendages previously shown by him, which could be little doubt were the same as Dr. Leidy's. It is to be wished that Dr. Leidy may publish figures of his Rhizopodous forms, embracing Difflugiæ, for it is sometimes difficult to express those often subtle but characterisic differences which these organisms present and withal seem to maintain.

17*th December*, 1874.

On the Ovary and Ovaries in Butomus umbellatus. — Dr. McNab exhibited three preparations of Flowering Rush, *Butomus umbellatus*, showing some peculiarities observable in that plant. (1) Transverse sections of the ovaries, showing six carpels arranged in two rows. The whole inner surface of each—with the exception, first, of the line corresponding to the midrib of the carpellary leaf, and secondly, the ventral suture or the edges of the carpels—is covered with ovules. These ovules are very numerous, but only a few are fertilized and form perfect seeds. (2) A preparation showing the development of the ovule and its coats; the ovules are anatropal, and exhibit in their young stages the nucleus, secundine, and primine. (3) Another preparation showing that in the ovules at the time of fertilization the secundine projects beyond the primine or outer coat, which is shortened. The micropyle is formed entirely by the projecting secundine, the two parts of the micropyle, namely, the exostome or opening in the primine and endostome or opening in the secundine, not being observable.

Rytiphlæa Baileyi (?) *from North America.*—Dr. E. Perceval Wright exhibited a portion of the type-specimen of *Rytiphlæa Baileyi* of Harvey, and contrasted it with a species of the same genus from North America, sent for comparison by Dr. Farlow. The specimen sent was not in fruit; the type-specimen only exhibited antheridia, so that until further material should turn up the very existence of this species must to a certain extent remain doubtful.

Malformation in Amphitetras.—Rev. E. O'Meara drew attention to a curious malformation in *Amphitetras antediluviana*, in which one of the four angles was greatly hypertrophied and broadly truncate. This remarkable and *outré* specimen was found in some material from the stomach of Ascidians taken at Roundstone Bay, Co. Galway.

Form of Cladophora glomerata.—Mr. Crowe showed noteworthy examples of a very thick-walled short-celled form of the somewhat polymorphous *Cladophora glomerata*, taken from a stream in the Chamounix valley.

New sp. of Mite (*obtained from human face*).—Dr. Macalister showed two specimens of a species of mite sent to him by Professor Cleland, of Galway. They had been taken off a lady's face by Dr. Freeman, in Jamaica, and were forwarded by him to Prof. Cleland. They were male and female, and apparently a new species, which Dr. Macalister hopes shortly to describe.

Problematic fungal growth.—Dr. Frazer drew attention to a minute, probably fungal organism, found by him on a painted metal flower-pot, forming little cuneiform bodies, attached by their narrow extremities, and apparently of a spongy tissue, and having a prettily villous surface, to the naked eye appearing as if transversely banded in at least three colours, white, green, and red, from below upwards; when examined under a moderate power, these colours passed more gradually into one another. There was not anything like fructification to be seen, but the specimens deserved a scrupulous examination.

Male Flowers of Dumorteuria irrigna.—Dr. Moore showed the male flowers of this plant. In Dr. Taylor's account of the male receptacles in 'Flor. Hib.,' part ii, p. 54, he states that "they are especially beset with short, straight, whitish hairs." Dr. Moore's specimen proved that these supposed short, straight, rigid hairs are flat hair-like scales, broad at the base and tapering to a sharp point; they are not straight, but much recurved in a radiating spiral manner round the base of the receptacle; they take their rise from the peduncle and cover over the greenish carnose portion amongst which the antheridia are placed when it is young. These flattish scale-like hairs formed a pretty object.

Structure of Spines of Echinothrix turcarum and E. calamaris.—Mr. Mackintosh exhibited sections of spines of the foregoing, which presented a wide diversity of structure. *E. turcarum* has the central hollow, which is moderate in size, surrounded by a solid ring, the lining calcification of the spine, with its usual foramina; next a zone of the reticulated tissue, bounded outside by an irregular ring, from which come off a number of elongate solid wedges, separated from one another by "spokes" of reticulated tissue. The sections are of a beautiful pink colour, although the spines are dark red, nearly approaching to black. The spine of *E. calamaris* are banded white and brown, and in section show an exceedingly wide central hollow, occupied by a loose reticulation in injured specimens; next, there is the solid ring, but much less distinct than in *E. turcarum*, and finally, on the outside, a series of solid pieces, shaped like an isosceles triangle, and joined here and there by transverse bars. As far as spine structure goes these two species tend in different directions; *E. turcarum* having affinities towards *Centro stephanus* and *Diadema*, and *E. calamaris* towards *Astropyga*, and the differences are sufficiently great as almost to justify Gray's genus *Garelia* for *E. turcarum*. However, the spines are said by Agassiz to vary greatly, at least in external appearance. He figures under the name *E. calamaris* sections which look exceedingly like those of *E. turcarum*, so that the question must be regarded as still *sub judice*.

Crystalline Structure in Shrimp-shell.—Mr. Porte exhibited sections of shell of shrimp showing a crystalline structure. He had been under the impression that the shell of crustaceans consisted of carbonate of lime segregated from the water and deposited, like chalk, in an amorphous condition; having, however, accidentally examined a section of crab-shell by Topping, he perceived what seemed somewhat like crystals or calcareous discs arranged in tolerably regular intervals. It occurred to him that if he could obtain the shell of some very young crustacean, or, better still, the skin of one that had recently cast its shell, he would be able to ascertain whether the first deposit of lime were crystalline or amorphous. Having by him some shells and skins of shrimps in various stages of development—none, indeed, in the exact condition he could have wished, that is to say, a day or two after casting its shell—he, however, took the thinnest he could find. He examined the thinnest part of it, near the edge, and was able to perceive that the first deposit consists of *crystals* of carbonate of lime of beautiful stellate and aigrette forms, not aggregated in masses, but scattered thinly over the skin with distinct naked patches between. On examining the sides and upwards towards the dorsal part of the shell he found the crystals packed more and more closely together, until finally the crystalline structure became indistinguishable, and, so far as he could make out, the interspaces being formed with amorphous granular particles like powdered chalk; indeed, he was not sure that the whole mass of crystals may not be finally transformed into something of that sort. All the crystals found were of such forms as he believed were found only in animal secretions, it therefore occurred to him that the first layer of crystals is secreted by the creature, and this layer forms a basis of attraction for the remaining portion, which is probably segregated from the water in the same manner as incrustations are formed on many substances immersed in water holding lime in solution, whilst on other substances immersed in the same water no deposit is formed.

Vacuolaria virescens, Cienk., *shown.*—Mr. Archer showed an encysted state of the flagellate *Vacuolaria virescens*, Cienkowski. Before making a note of it here, however, he desired to refind some examples; this organism is somewhat local in its occurrence, but in its own situations sometimes occurs in considerable quantity.

Bacterium rubescens, Lankester, *exhibited on part of Mr. Lankester.*—Mr. Archer showed examples kindly given to him by Mr. Ray Lankester of his remarkable *Bacterium rubescens.* Mr. Archer at same time drew attention to Mr. Lankester's figures accompanying his valuable memoir thereon, as well as to some related forms of undoubted algal nature opportunely turning up. When Mr. Lankester showed this organism to him, on the occasion of the meeting of the British Association at Belfast, he was under the impression it might turn out to be identical with some one of the things now on the table, only in much more exuberant condition of growth, having an affinity to that named *Clathrocystis aeruginosa* by Henfrey, or that named *Monostroma rosea* by Currey; but though no doubt "related," and probably an *alga*, Mr. Archer thought he could most safely say Mr. Lankester's *B. rubescens* was *not identical* with any of them.

Staurogenia rectangularis (Morren), A. Braun, *exhibited.*—Mr. Archer showed the rather uncommon minute alga *Staurogenia rectangularis*, A. Braun = *Crucigenia rectangularis*, Morren = *Chloropedium rectangulare*, Näg. On the appearance of Mr. Archer's paper in reference to the genus *Tetrapedia*, Reinsch, in the 'Quart. Journ. Micr. Science,' M. Morren, fil., was under the impression that *Tetrapedia* was but a new name for the same or one very similar to the organism discovered by his father, but it is not so. They are essentially distinct things—the present plant is chlorophyllaceous, Tetrapedia phycochromaceous.

MEMOIRS.

A Comparison *of the* Early Stages *in the* Development *of* Vertebrates. By F. M. Balfour, B.A., Fellow of Trinity College, Cambridge. (With Plate X.)

If the genealogical relationships of animals are to be mainly or largely determined on embryological evidence, it becomes a matter of great importance to know how far evidence of this kind is trustworthy.

The dependence to be placed on it has been generally assumed to be nearly complete. Yet there appears to be no *à priori* reason why natural selection should not act during the embryonic as well as the adult period of life; and there is no question that during their embryonic existence animals are more susceptible to external forces than after they have become full grown: indeed, an immense mass of evidence could be brought to show that these forces do act upon embryos, and produce in them great alterations tending to obscure the genealogical inferences to be gathered from their developmental histories. Even the time-honoured layers form to this no exception. In *Elasmobranchs,* for instance, we find the notochord derived from the hypoblast and the spinal ganglia derived from the involuted epiblast of the neural canal, whilst in the higher vertebrates both of these organs are formed in the mesoblast. Such instances are leading embryologists to recognize the fact that the so-called layers are not quite constant and must not be absolutely depended upon in the determination of homologies. But though it is necessary to recognise the fact that great changes do occur in animals during their embryonic life, it is not necessary to conclude that all embryological evidence is thereby vitiated; but rather it becomes incumbent on us to attempt to determine which embryological features are ancestral and which secondary. For this purpose it is requisite to ascertain what are the general characters of secondary features and how they are produced. Many vertebrates have in the first stages of their development a number of secondary characters which are due to the presence of food material in the ovum; the present essay is mainly an attempt to indicate how those secondary characters arose and to trace their gradual development. At the same time certain important ancestral characters of the early phases of the development of vertebrates, especially with reference to the formation of the hypoblast and mesoblast, are pointed out and their meaning discussed.

There are three orders of vertebrates of which no mention has been made, viz., the *Mammals*, the *Osseous* fishes, and the *Reptiles*. The first of these have been passed over because the accounts of their development are not sufficiently satisfactory, though as far as can be gathered from Bischoff's account of the dog and rabbit there would be no difficulty in showing their relations with other vertebrates.

We also require further investigations on Osseous fishes, but it seems probable that they develop in nearly the same manner as the Elasmobranchs.

With reference to Reptiles we have no satisfactory investigations.

Amphioxus is the vertebrate whose mode of development in its earliest stages is simplest, and the modes of development of other vertebrates are to be looked upon as modifications of this due to the presence of food material in their ova. It is not necessary to conclude from this that Amphioxus was the ancestor of our present vertebrates, but merely that the earliest stages of development of this vertebrate ancestor were similar to those of Amphioxus.

The ovum of Amphioxus contains very little food material and its segmentation is quite uniform. The result of segmentation is a vesicle whose wall is formed of a single layer of cells. These are all of the same character, and the cavity of the vesicle called the segmentation cavity is of considerable size. A section of the embryo, as we may now call the ovum, is represented in Plate X, fig. A I.

The first change which occurs is the pushing in of one half of the wall of the vesicle towards the opposite half. At the same time by the narrowing of its mouth the hollow hemisphere so formed becomes again a vesicle.[1]

[1] I have been able to make at Naples observations which confirm the account of the invagination of Amphioxus as given by Kowalevsky, though my observations are not nearly so complete as those of the Russian naturalist.

Owing to its mode of formation the wall of this secondary vesicle is composed of two layers which are only separated by a narrow space, the remnant of the segmentation cavity.

Two of the stages in the formation of the secondary vesicle by this process of involution are shown in Plate X, fig. A II, and A III. In the second of these the general growth has been very considerable, rendering the whole animal much larger than before. The cavity of this vesicle, A III, is that of the commencing alimentary canal whose final form is due to changes of shape undergone by this primitive cavity. The inner wall of the vesicle becomes converted into the wall of the alimentary canal or hypoblast, and also into part or the whole of the mesoblast.

During the involution the cells which are being involuted undergo a change of form, and before the completion of the process have acquired a completely different character to the cells forming the external wall of the secondary vesicle or epiblast. This change of character in the cells is already well marked in fig. A II. It is of great importance, since we shall find that some of the departures from this simple mode of development, which characterise other vertebrates, are in part due to the distinction between the hypoblast and epiblast cells appearing during segmentation, and not subsequently as in Amphioxus during the involution of the hypoblast.

Kowalevsky ('Entwickelungeschichte des Amphioxus') originally believed that the narrow mouth of the vesicle (according to Mr. Lankester's terminology *blastopore*) became the anus of the adult. He has since, and certainly correctly, given up this view. The opening of the involution becomes closed up and the adult anus is no doubt formed as in all other vertebrates by a pushing in from the exterior, though it probably corresponds in position very closely with the point of closing up of the original involution.

The mode of formation of the mesoblast is not certainly known in Amphioxus; we shall find, however, that for all other vertebrates it arises from the cells which are homologous with the involuted cells of this animal.

Since food material is a term which will be very often employed, it will be well to explain exactly the sense in which it will be used. It will be used only with reference to those passive highly refractive particles which are found embedded in most ova.

In some eggs, of which the hen's egg may be taken as a familiar example, the yolk spherules or food material form the larger portion of the ovum, and a distinction is frequently made between the germinal disc and the yolk.

This distinction is, however, apt to lead to a misconception of the true nature of the egg. There are strong grounds for believing that the so-called yolk, equally with the germinal disc, is composed of an active protoplasmic basis endowed with the power of growth, in which passive yolk spherules are embedded; but that the part ordinarily called the yolk contains such a preponderating amount of yolk spherules that the active basis escapes detection, and does not exhibit the same power of growth as the germinal disc.

With the exception of mammals, whose development requires to be more completely investigated, Amphioxus is as far as we know the only vertebrate whose ovum does not contain a large amount of food material.

In none of these (vertebrate) yolk-containing ova is the food material distributed uniformly. It is always concentrated much more at one pole than at the other, and the pole at which it is most concentrated may be conveniently called the lower pole of the egg.

In eggs in which the distribution of food material is not uniform segmentation does not take place with equal rapidity through all parts of the egg, but its rapidity is, roughly speaking, inversely proportional to the quantity of food material.

When the quantity of food material in a part of the egg becomes very great, segmentation does not occur at all; and even in those cases where the quantity of food yolk is not too great to prevent segmentation the resulting segmentation spheres are much larger than where the yolk-granules are more sparsely scattered.

The frog is the vertebrate whose development comes nearest to that of Amphioxus, as far as the points we are at present considering are concerned. But it will perhaps facilitate the understanding of their relations shortly to explain the diagrammatic sections which I have given of an animal supposed to be intermediate in its development between the Frog and Amphioxus. Plate X, fig. B I, represents a longitudinal section of this hypothetical egg at the close of segmentation. The lower pole, coloured green, represents the part containing more yolk material, and the upper pole, coloured yellow, that with less yolk. Owing to the presence of this yolk the lower pole even at the close of segmentation is composed of cells of a different character to those of the upper pole. In this respect this egg can already be distinguished from that of Amphioxus, in which no such difference between the two poles is apparent at the corresponding period (Plate X, fig. A I).

The segmentation cavity in this ovum is not quite so large proportionately as in Amphioxus, and the encroachment upon it is due to the larger bulk of the lower pole of the egg. In fig. B II, the involution of the lower pole has already commenced; this involution is (1) not quite symmetrical, and (2) on the ventral side (the left side) the epiblast cells forming the upper part of the egg are growing round the cells of the lower pole of the egg or lower-layer cells. Both of these peculiarities are founded upon what happens in the Frog and the Selachian, but it is to be noticed that the change from the lower layer cells being involuted towards the epiblast cells, to the epiblast cells growing round the lower layer cells, is a necessary consequence of the increased bulk of the latter.

In this involution not only are the cells of the lower pole pushed on, but also some of those of the upper or yellow portion; so that in this as in all other cases the true distinction between the epiblast and hypoblast does not appear till the involution to form the latter is completed. In the next stage, B III, the involution has become nearly completed and the opening to the exterior or Blastopore quite constricted.

The segmentation cavity has been entirely obliterated, as would have been found to be the case with Amphioxus had the stage a little older than that on Plate X, A III, been represented. The cavity marked (*a l*), as was the case with amphioxus, is that of the alimentary canal.

The similarities between the mode of formation of the hypoblast and alimentary canal in this animal and in Amphioxus are so striking and the differences between the two cases so slight that no further elucidation is required. One or two points need to be spoken of in order to illustrate what occurs in the Frog. When the involution to form the alimentary canal occurs, certain of the lower layer cells (marked *h y*) become distinguished from the remainder of the lower layer cells as a separate layer and form the hypoblast which lines the alimentary canal. It is to be noticed that the cells which form the ventral epithelium of the alimentary canal are not so soon to be distinguished from the other lower layer cells as those which form its dorsal epithelium. This is probably a consequence of the more active growth, indicated by the asymmetry of the involution, on the dorsal side, and is a fact with important bearings in the ova with more food material. The cells marked *m* and coloured red also become distinguished as a separate layer from the remainder of the hypoblast and form the mesoblast. The remainder of the lower layer cells form a mass equivalent to the yolk-sac of many vertebrates, and are not converted directly into the tissues of the animal.

Another point to be noticed is the different relation of epiblast cells to the hypoblast cells at the upper and lower side of the mouth of the involution. Above it, on its dorsal side, the epiblast and hypoblast are continuous with one another. On its ventral side they are primitively not so continuous. This is due to the epiblast, as was before mentioned, growing round the lower layer cells on the ventral side, *vide* B II, and merely remaining continuous with them on the dorsal. The importance of these two points will appear when we come to speak of other vertebrates.

The next animal whose development it is necessary to speak of is the Frog, and its differences from the mode of development are quite easy to follow and interpret. Segmentation is again not uniform, and results in the formation of an upper layer of smaller cells and a lower one of larger; in the centre is a segmentation cavity. The stage at the close of segmentation is represented in C I. From the diagram it is apparent that lower layer cells occupy a larger bulk than they did in the previous animal (Plate X, B I), and tend to encroach still more upon the segmentation cavity, otherwise the differences between the two are unimportant. There are, however, two points to be noted. In the first place, although the cells of the upper pole are distinguished in the diagrams from the lower by their colour, it is not possible at this stage to say what will become epiblast and what hypoblast. In the second place the cells of the upper pole or epiblast consist of two layers—an outer called the epidermic layer and an inner called the nervous. In the previous cases the epiblast consisted of a single layer of cells. The presence of these two layers is due to a distinction which, arising in most other vertebrates late, in the Frog arises early. In most other vertebrates in the later stages of development the epiblast consists of an outer layer of passive and an inner of active cells. In the Frog and other Batrachians these two layers become distinguished at the commencement of development.

In the next stage (C II) we find that the involution to form the alimentary canal has commenced (*a l*), but that it is of a very different character to involution in the previous case. It consists in the growing inwards of a number of cells from the point *x* (C I) towards the segmentation cavity. The cells which grow in this way are partly the yellow cells and partly the smaller green ones. At first this involuted layer of cells is only separated by a slit from the remainder of the lower layer cells; but by the stage represented in C II this has widened into an elongated cavity (*a l*). In its formation this involution pushes backwards the segmentation cavity, which finally disappears in the stage C III. The point *x* remains practically stationary, but by the general growth of the epiblast, mesoblast, and hypoblast, becomes further removed from the segmentation cavity in C II than in C I. On the opposite side of the embryo to that at which the involution occurs the epiblast cells as before, grow round the lower layer cells. The commencement of this is already apparent in C I, and in C II the process is nearly completed, though there is still a small mass of yolk filling up the blastopore. The features of this involution are in the main exaggerations of what was supposed to occur in the previous animal. The asymmetry of the involution is so great that it is completely one-sided and results, in the first instance, in a mere slit; and the whole process of enclosing the yolk by epiblast is effected by the epiblast cells on the side of the egg opposite to the involution.

The true mesoblast and hypoblast are formed precisely as in the previous case. The involuted cells become separated into two layers, one forming the dorsal epithelium of the alimentary canal, and a layer between this and the epiblast forming the mesoblast. There is also a layer of mesoblast accompanying the epiblast which encloses the yolk, which is derived from the smaller green cells at *y* (C I). The edge of this mesoblast, *m′*, forms a thickened ridge, a feature which persists in other vertebrates.

It is a point of some importance for understanding the relation between the mode of formation of the alimentary canal in the frog and other vertebrates to notice that on the ventral surface the cells which are to form the epithelium of the alimentary canal become distinguished as such very much later than do those to form its dorsal epithelium, and are derived not from the involuted cells but from the primitive large yolk-cells. It is indeed probable that only a very small portion of epithelium of the ventral wall of the mid-gut is in the end derived from these larger yolk-cells. The remainder of the yolk-cells (C III, and C II, *yk*) form the yolk mass and do not become directly formed into the tissues of the animal.

In the last stage I have represented for the frog, C III, there are several features to be noticed.

The direct connection at their hind-ends between the cavities of the neural and alimentary canals is the most important of these. This is a result of the previous continuity of the epiblast and hypoblast at the point x, and is a feature almost certainly found in Amphioxus, but which I will speak of more fully in my account of the Selachian's development. The opening of the blastopore called the anus of Rusconi is now quite narrowed, it does not become the anus of the adult. It may be noticed that at the front end of the embryo the primitive dorsal epithelium of the alimentary canal is growing in such a way as to form the epithelium both of the dorsal and ventral surfaces of the foregut.

In spite of various features rendering the development of the frog more difficult of comprehension than that of most other vertebrates, it is easy to see that the step between it and Amphioxus is not a very great one, and will very likely be bridged over at some future time, when our knowledge of the development of other forms becomes greater.

From the frog to the Selachian is a considerable step, but I have again hypothetically sketched a type intermediate between them whose development agrees in some important points with that of *Pelobates fuscus* as described by Bambeke. The points of agreement, though not obvious at first sight, I shall point out in the course of my description.

The first stage (D I), at the close of segmentation, deserves careful attention. The segmentation cavity by the increase of the food yolk is very much diminished in size, and, what is still more important, has as it were sunk down so as to be completely within the *lower layer cells.* The roof of the segmentation cavity is thus formed of epiblast and lower layer cells, a feature which Bambeke finds in *Pelobates fuscus* and which is certainly found in the Selachians. In the Frog we found that the segmentation cavity began to be encroached on by the lower layer cells, and from this it is only a small step to find these cells creeping still further up and forming the roof of the cavity. In the lower layer cells themselves we find an important new feature, viz. that during segmentation they become divided in two distinct parts—one of these where the segments owing to the presence of much food yolk are very large, and the other where the segments are much smaller.

The separation between these two is rather sharp. Even this separation was foreshadowed in the frog's egg, in which a number of lower layer cells were much smaller and more active at the two sides of the segmentation cavity than elsewhere. The segmentation cavity at first lies completely within the region of the small spheres. The larger cells serve almost entirely as food yolk. The epiblast, as is normal with vertebrates, consists of a single layer of columnar cells.

In the next stage (D II) the formation of the alimentary canal (*al*) has commenced, but it is to be observed that there is in this case *no true involution.*

As an accompaniment to the encroachment upon the segmentation cavity, which was a feature of the last stage, the cells to form the walls of the alimentary canal have come to occupy their final position during segmentation and without the intermediation of an involution, and traces only of the involution, are to be found in (1) a split in the lower layer cells which passes along the line separating the small and the large lower layer cells; and (2) in the epiblast becoming continuous with the hypoblast on the dorsal side of the mouth of this split. It is even possible that at this point a few cells (though certainly only a very small number) of those marked yellow in D I become involuted. This point in this, as in all other cases, is the tail end of the embryo. The other features of this stage are as follows:—(1) The segmentation cavity has become smaller and less conspicuous than it was. (2) The epiblast cells have begun to grow round the yolk even in a more conspicuous manner than they did in the frog, and are accompanied by a layer of mesoblast cells which again becomes thickened at its edge. The mesoblast cells in the region of the body are formed in the same way as before, viz. by the separation of a layer to form the epithelium of the alimentary canal, the other cells remaining as mesoblast; and as in the frog, or in a more conspicuous manner, we find that the dorsal surface only of the alimentary cavity has a wall formed of a *distinct layer of cells,* but on the ventral side the cavity is at first closed in by the large spheres of the yolk only. The formation of the alimentary canal by a split and not by an involution is exactly what Bambeke finds in *Pelobates.*

The next stage, D III, is about an equivalent age to C III in the frog. It exhibits the same connection between the neural and the alimentary canals as was found there.

The alimentary canal is beginning to become closed in below, and this occurs near the two ends earlier than in the middle. The cells to form the ventral wall are derived from the large yolk-cells. The non-formation of the ventral wall of the alimentary canal so soon in the middle as at the ends is an early trace of the umbilical canal found in Birds and Selachians, by which the alimentary tract is placed in communication with the yolk-sac. The segmentation cavity has by this stage completely vanished, and the epiblast with its accompanying mesoblast has spread completely round the yolk material so as to form the ventral wall of the body.

Though in some points this manner of development may seem to differ from that of the Frog, there is really a fundamental agreement between the two, and between this mode of development and that of the Selachians we shall find the agreement to be very close.

After segmentation we find that the egg of a selachian consists of two parts—one of these called the germinal disc or blastoderm, and the other the yolk. The former of these corresponds with the epiblast and the part of the lower pole composed of smaller segments in the last-described egg, and the latter to the larger segments of the lower pole. This latter division, owing to the quantity of *yolk* which it contains, has not undergone segmentation, but its homology with the larger segments of the previous eggs is proved (1) by its containing a number of nuclei (E I, *n*), which become the nuclei of true cells and enter the blastoderm, and (2) by the presence in it of a number of lines forming a network similar to that of many cells. The segmentation cavity, as before, lies completely within the lower layer cells.

The next stage, E II, is almost precisely similar to the second stage of the last egg. As there, the primitive involution is merely represented by a split separating the yolk and the germinal disc, and on the dorsal side alone is there a true cellular wall for this split, and at the dorsal mouth of the split the alimentary epithelium becomes continuous with the epiblast.

The segmentation cavity has become diminished, and round the yolk the epiblast, accompanied by a layer of mesoblast, is commencing to grow. In this growth all parts of the blastoderm take a share except that part where the epiblast and hypoblast are continuous. This manner of growth is precisely what occurs in the Frog, though there it is not so easily made out; and not all the investigators who have studied the Frog have understood the exact meaning of the appearances they have seen and drawn. This similarity of relation of the epiblast to the yolk in the two cases is a further confirmation of the identity of the Selachian's yolk with the large yolk-spheres of the previous eggs.

The next stage, E III, is in many ways identical with the corresponding stage in the last-described egg, and in the same way as in that case the neural and alimentary canals are placed in communication with each other.

The mode in which this occurs will be easily gathered from a comparison of E II and E III. It is the same for the

Selachians and Batrachians. The neural canal (*n c*) is by the stage figured E III, completely formed in the way so well known in the Bird, and between the roof of the canal and the external epiblast a layer of mesoblast has already grown in. The floor of the neural canal is the same layer marked *ep* in E II, and therefore remains continuous with the hypoblast at *x*; and when by a simultaneous process the roof of the neural canal and the ventral wall of the alimentary become formed by the folding over of one continuous layer (the epiblast and hypoblast continuous at the point *x*), the two canals, viz. the neural and alimentary, are necessarily placed in communication at their hind ends, as is seen in the diagram.

There are several important points of difference between E III and D III. In the first place, owing to the larger size of the yolk-mass in E III, the epiblast, accompanied by mesoblast, has not proceeded nearly so far round it as in the previous case. It is also worth notice that at the right as well as at the left end of the germinal disc the epiblast is commencing to grow round the yolk. The yolk has, however, become surrounded to a much smaller extent on the right hand than on the left. Since, in the earlier stage, the epiblast became continuous with the hypoblast at *x*, it is not from sections obvious how this occurs. I have therefore appended a diagram to explain it (E′). The blastoderm rests like a disc on the yolk and grows over it on all sides, except at the point where the epiblast and hypoblast are continuous (*x*). This point becomes as it were left in a bay. Next the two sides of the bay coalesce, the bay becomes obliterated, and the effect produced is exactly as if the blastoderm had grown round the yolk at the point *x* (corresponding with the tail of the embryo) as well as everywhere else. It thus comes about that the final point where the various parts of the blastoderm meet and completely enclose the yolk mass does not correspond with the anus of Rusconi of the Frog, but is at some little distance from the hind end of the embryo. In other words, the position of the blastopore in the Selachian is not the same as in the Frog.

Another point deserving attention is the formation of the ventral wall of the alimentary canal. This takes place in two ways—partly by a folding-in at the sides and end, and partly from cells formed around the nuclei (*n*) in the yolk. From these a large portion of the ventral wall of the midgut is formed.

The folding-in of the sheet of hypoblast to assist in the closing-in of the ventral wall of the alimentary canal is a consequence of the flattened form of the original alimentary slit which is far too wide to form the cavity of the final canal. In the bird whose development must next be considered this folding-in is a still more prominent feature in the formation of the alimentary canal. As in the last case, the alimentary canal is widely open in the middle to the yolk at the time when its two ends are closed below and shut off from it; still later this opening becomes very narrow and forms the duct of the so-called umbilical cord which places the yolk-sac in communication with the alimentary canal. As the young animal becomes larger the yolk-sac ceases to communicate directly with the alimentary canal, and is carried about by it for some time as an appendage and only at a later period shrivels up.

The mesoblast is formed in a somewhat different way in the sharks than in other vertebrates. It becomes split off from the hypoblast, not in the form of a single sheet as in other vertebrates, but as two lateral sheets, one on each side of the middle line and separated from one another by a considerable interval; whilst the notochord is derived not as in other vertebrates from the mesoblast, but from the hypoblast (*vide* F. M. Balfour, "Development of Selachians," 'Journal of Microscopical Science,' Oct., 1874).

Between the Selachians and the Aves there is a considerable gulf, which it is more difficult satisfactorily to bridge over than in the previous cases; owing to this I have not attempted to give any intermediate stage between them.

The first stage of the Bird (F I) is very similar in many respects to the corresponding stage in the Selachian. The segmentation cavity is, however, a less well-defined formation, and it may even be doubted whether a true segmentation cavity, homologous with the segmentation cavity in the previously described egg, is present. On the floor of the cavity which is the case formed by the yolk are a few larger cells known as formative cells which, according to Götte's observations, are derived from the yolk, in a somewhat similar manner to the cells which were formed around the nuclei in the Selachian egg, and which helped to form the ventral wall of the alimentary canal. Another point to be noticed is that the segmentation cavity occupies a central position, and not one to the side as in the Selachian.

The yolk is proportionately quite as large as in the Selachian's egg, but, as in that case, there can be little or no doubt of its being homologous with the largest of the segmentation spheres of the previous eggs. It does not undergo segmentation. The epiblast is composed of columnar cells, and extends a short way beyond the edge of the lower layer cells.

In the next stage the more important departures from the previous type of development become visible.

The epiblast spreads uniformly over the yolk-sac and not on the one side only as in the former eggs.

This is due to the embryo (indicated in F II by a thickening of the cells) lying in the centre and not at the edge of the blastoderm. A necessary consequence of this is, that the epiblast does not, as in the previous cases, become continuous with the hypoblast at the tail end of the embryo. This continuity, being of no functional importance, could easily be dispensed with, and the central position of the embryo may perhaps be explained by supposing the process, by which in the Selachian egg the blastopore ceases to correspond in position with the opening of the alimentary slit or anus of Rusconi (*vide* E′), to occur quite early during segmentation instead of at a late period of development. For the possibility of such a change in the date of formation, the early appearance of the nervous and epidermic layers in the Frog affords a parallel.

The epiblast in its growth round the yolk is only partially accompanied by mesoblast, which, however, is thickened at its extreme edge as in the frog. Owing to the epiblast not becoming continuous with the hypoblast at the tail end of the embryo, the alimentary slit is not open to the exterior. The hypoblast is formed by some of the lower layer cells becoming distinguished as a separate layer; the remainder of the lower layer cells become the mesoblast.

The formation of the mesoblast and hypoblast out of the lower layer cells has been accepted for the Bird by most observers, but has been disputed by several, and recently by Kölliker. These have supposed that the mesoblast is derived from the epiblast. I feel convinced that these observers are in the wrong, and that the mesoblast is genuinely derived from the lower layer cells.

The greater portion of the alimentary cavity consists of the original segmentation cavity (*vide* diagrams). This feature of the segmentation cavity of Birds sharply distinguishes it from any segmentation cavity of other eggs, and renders it very doubtful whether the similarly named cavities of the Bird and of other vertebrates are homologous. On the floor of the cavity are still to be seen some of the formative cells, but observers have not hitherto found that they take any share in forming the ventral wall of the alimentary canal.

The features of the next stage are the necessary consequences of those of the last.

The ventral wall of the alimentary canal is entirely formed by a folding-in of the sheet of hypoblast.

The more rapid folding-in at the head still indicates the previous more vigorous growth there, otherwise there is very little difference between the forms of the fold at the head and tail. The alimentary canal does not of course, at this or any period, communicate with the neural tube, since the epiblast and hypoblast are never continuous. The other features, such as the growth of the epiblast round the yolk-sac, are merely continuations of what took place in the last stage.

In the development of a yolk-sac as a distinct appendage, and its absorption within the body, at a later period, the bird fundamentally resembles the dog fish.

Although there are some difficulties in deriving the type of development exhibited by the Bird directly from that of the Selachian, it is not very difficult to do so directly from Amphioxus. Were the alimentary involution to remain symmetrical as in Amphioxus, and the yolk-containing part of the egg to assume the proportions it does in the Bird, we should obtain a mode of development which would not be very dissimilar to that of the Bird. The epiblast would necessarily overgrow the yolk uniformly on all sides and not in the unsymmetrical fashion of the Selachian egg. A confirmation of this view might perhaps be sought for in the complete difference between the types of circulation of the yolk-sac in Birds and Selachians; but this is not so important as might at first sight appear, since it is not from the Selachian egg but from some Batrachian that it would be necessary to derive the Reptiles' and Birds' eggs.

If this view of the bird's egg be correct, we are compelled to suppose that the line of ancestors of birds and reptiles did not include amongst them the Selachiansand the Batrachians, or at any rate Selachians and Batrachians which develope on the type we now find.

The careful investigation of the development of some reptiles might very probably throw light upon this important point. In the meantime it is better to assume that the type of development of birds is to be derived from that of the Frog and Selachians.

Summary.—If the views expressed in this paper are correct, all the modes of development found in the higher vertebrates are to be looked upon as modifications of that of Amphioxus. It is, however, rather an interesting question whether it is possible to suppose that the original type was *not* that of Amphioxus, but of some other animal, say, for instance, that of the Frog, and that this varied in two directions,—on the one hand towards Amphioxus, in the reverse direction to the course of variation presupposed in the text; and on the other hand in the direction towards the Selachians as before.

The answer to this question must in my opinion be in the negative. It is quite easy to conceive the food material of the Frog's egg completely vanishing, but although this would entail simplifications of development and possibly even make segmentation uniform, there would, as far as I can see, be no cause why the essential features of difference between the Frog's mode of development and that of Amphioxus should change. The asymmetrical and slit-like form of involution on the one side and the growth of the epiblast over the mesoblast on the other side, both characteristics of the present Frog's egg, would still be features in the development of the simplified egg.

In the Mammal's egg we probably have an example of a Reptile's egg simplified by the disappearance of the food material; and when we know more of Mammalian embryology it will be very interesting to trace out the exact manner in which this simplification has affected the development. It is also probable that the eggs of Osseous fish are fundamentally simplified Selachian eggs; in which case we already know that the diminution of food material has affected but very slightly the fundamental features of development.

One common feature which appears prominently in reviewing the embryology of vertebrates as a whole is the derivation of the mesoblast from the hypoblast; in other words, we find that it is from the layer corresponding to that which becomes involuted in Amphioxus so as as to line the alimentary cavity that the mesoblast is split off.

That neither the hypoblast or mesoblast can in any sense be said to be derived from the epiblast is perfectly clear. When the egg of Amphioxus is in the blastosphere stage we cannot speak of either an epiblast or hypoblast. It is not till the involution or what is equivalent has occurred, converting the single-walled vesicle into a double-walled one, that we can speak of these two layers. It might seem scarcely necessary to insist upon this point, so clear is it without explanation, were it not that certain embryologists have made a confusion about it.

The derivation of the mesoblast from the hypoblast is the more interesting, since it is not confined to the vertebrates, but has a very wide extension amongst the invertebrates. In the cases (whose importance has been recently insisted upon by Professor Huxley), of the Asteroids, the Echinoids, Sagitta, and others, in which the body cavity arises as an outgrowth of the alimentary canal and the somatopleure and splanchnopleure are formed from that outgrowth, it is clear without further remark that the mesoblast is derived from the hypoblast. For the echinoderms in which the water-vascular system and muscular system arise as a solid outgrowth of the wall of the alimentary canal there can also be no question as to the derivation of the mesoblast from the hypoblast.

Amongst other worms, in addition to Sagitta, the investigations of Kowalevsky seem to show that in Lumbricus the mesoblast is derived from the hypoblast.

Amongst Crustaceans, Bobretzky's[1] observations on Oniscus ('Zeitschrift fur wiss. Zoologie,' 1874) lead to the same conclusion.

In insects Kowalevsky's observations lead to the conclusion that mesoblast and hypoblast arise from a common mass of cells; Ulianin's observations bring out the same result for the abnormal Poduridæ, and Metschnikoff's observations show that this also holds for Myriapods.

In mollusks the point is not so clear.

In Tunicates, even if we are not to include them amongst vertebrates,[2] the derivation of mesoblast from hypoblast is without doubt.

Without going further into details it is quite clear that the derivation of the mesoblast from the hypoblast is very general amongst invertebrates.

It will hardly be disputed that primitively the muscular system of the body wall could not have been derived from the layer of cells which lines the alimentary canal. We see indeed in Hydra and the Hydrozoa that in its primitive differentiation, as could have been anticipated beforehand, the muscular system of the body is derived from the epiblast cells. What, then, is the explanation of the widespread derivation of the mesoblast, including the muscular system of the body, from the hypoblast?

The explanation of it may, I think, possibly be found, and at all events the suggestion seems to me sufficiently plausible to be worth making, in the fact that in many cases, and probably this applies to the ancestors of the vertebrates, the body cavity was primitively a part of the alimentary.

[1] He says, p. 182: "Bevor aber die Hälfte der Eioberfläche von den Embryonalzellen bedeckt ist, kommt die erste gemeinsame Anlage des mittleren und unteren Keimblattes zum Vorschein."

[2] Anton Dohrn, 'Der Ursprung des Wirbelthieres.' Leipzig, 1875.

Mr. Lankester, who has already entered into this line of speculation, even suggests ('Q. J. of Micr. Science,' April, 1875) that this applies to all higher animals. It might then be supposed that the muscular system of part of the alimentary canal took the place of the primitive muscular system of the body; so that the whole muscular system of higher animals would be primitively part of the muscular system of the digestive tract.

I put this forward merely as a suggestion, in the truth of which I feel no confidence, but which may perhaps induce embryologists to turn their attention to the point. If we accept it for the moment, the supplanting of the body muscular system by that of the digestive tract may hypothetically be supposed to have occurred in the following way.

When the diverticulum or rather paired diverticula were given off from the alimentary canal they would naturally become attached to the body wall, and any contractions of their intrinsic muscles would tend to cause movements in the body wall. So far there is no difficulty, but there is a physiological difficulty in explaining how it can have happened that this secondary muscular system can have supplanted the original muscular system of the body.

The following suggestions may lessen this difficulty, though perhaps they hardly remove it completely. If we suppose that the animal in which these diverticula appeared had a hard test and was not locomotive, the intrinsic muscular system of the body would naturally completely atrophy. But since the muscular system of the diverticula from the stomach would be required to keep up the movement of the nutritive fluid, it would not atrophy, and were the test subsequently to become soft and the animal locomotive, would naturally form the muscular system of the body. Or even were the animal locomotive in which the diverticula appeared, it is conceivable that the two systems might at first coexist together; that either (1) subsequently owing to the greater convenience of early development, the two systems might acquire a development from the same mass of cells and those the cells of the inner or hypoblast layer, so that the derivation of the body muscles from the hypoblast would only be apparent and not real, or (2) owing to their being better nourished as they would necessarily be, and to their possibly easier adaptability to some new form of movement of the animal, the muscle-cells of the alimentary canal might become developed exclusively whilst the original muscular system atrophied.

I only hold this view provisionally till some better explanation is given of the cases of Sagitta and the Echinoderms, as well as of the nearly universal derivation of the mesoblast from the hypoblast. The cases of this kind may be due to some merely embryonic changes and have no meaning in reference to the adult condition, but I think that we have no right to assume this till some explanation of the embryonic can be suggested.

For vertebrates, I have shown that in Selachians the body cavity at first extends quite to the top of what becomes the muscle plate, so that the line or space separating the two layers of the muscle plate (*vide* Balfour, "Development of Elasmobranch Fishes," 'Quart. Journ. of Micro. Science' for Oct., 1874. Plate XV, fig. 11 *a*, 11 *b*, 12 *a*, *mp*.) is a portion of the original body cavity. If this is a primitive condition, which is by no means certain, we have a condition which we might expect, in which both the inner and the outer wall of the primitive body cavity assists in forming the muscular system of the body.

It is very possible that the formation of the mesoblast as two masses, one on each side of the middle line as occurs in Selachians, and which as I pointed out in the paper quoted above also takes place in some worms, is a remnant of the primitive formation of the body cavity as paired outgrowth of the alimentary canal. This would also explain the fact that in Selachians the body cavity consists at first of two separate portions, one on each side of the alimentary canal, which only subsequently become united below and converted into a single cavity (*vide* loc. cit., Plate XIV; fig. 8 *b*, *pp*.)

In the Echinoderms we find instances where the body cavity and water-vascular system arise as an outgrowth from the alimentary canal, which subsequently becomes constricted off from the latter (asteroids and echinoids), together with other instances (ophiura, synapta) where the water-vascular system and body cavity are only secondarily formed in a solid mass of mesoblast originally split off from the walls of the alimentary canal.

These instances show us how easily a change of this kind may take place, and remove the difficulty of understanding why in vertebrates the body cavity never communicates with the alimentary.

The last point which I wish to call attention to is the blastopore or anus of Rusconi.

This is the primitive opening by which the alimentary canal communicates with the exterior, or, in other words, the opening of the alimentary involution. It is a distinctly marked structure in Amphioxus and the Batrachians, and is also found in a less well-marked form in the Selachians; in

Birds no trace of it is any longer to be seen. In all those vertebrates in which it is present, it closes up and does not become the anus of the adult. The final anus nevertheless corresponds very closely in position with the anus of Rusconi. Mr. Lankester has shown ('Quart. Journ. of Micro. Science' for April, 1875) that in invertebrates as well as vertebrates the blastopore almost invariably closes up. It nevertheless corresponds as a rule very nearly in position either with the mouth or with the anus.

If this opening is viewed, as is generally done, as really being the mouth in some cases and the anus in others, it becomes very difficult to believe that the blastopore can in all cases represent the same structure. In a single branch of the animal kingdom it sometimes forms the mouth and sometimes the anus: thus for instance in Lumbricus it is the mouth (according to Kowalevsky), in Palæmon (Bobretzky) the anus. Is it credible that the mouth and anus have become changed, the one for the other?

If, on the other hand, we accept the view that the blastopore never becomes either the one or the other of these openings, it is, I think, possible to account for its corresponding in position with the mouth in some cases or the anus in others.

That it would soon come to correspond either with the mouth or anus (probably with the earliest formed of these in the embryo), wherever it was primitively situated, follows from the great simplification which would be effected by its doing so. This simplification consists in the greater facility with which the fresh opening of either mouth or anus could be made where the epiblast and hypoblast were in continuity than elsewhere. Even a change of correspondence from the position of the mouth to that of the anus or *vice versa* could occur. The mode in which this might happen is exemplified by the case of the Selachians. I pointed out in the course of this paper how the final point of envelopment of the yolk became altered in Selachians so as to cease to correspond with the anus of Rusconi; in other words, how the position of the Blastopore became changed. In such a case, if the yolk material again became diminished, the Blastopore would correspond in position with neither mouth nor anus, and the causes which made it correspond in position with the anus before, would again operate, and make it correspond in position perhaps with the mouth. Thus the blastopore might absolutely cease to correspond in position with the anus and come to correspond in position with the mouth.

It is hardly possible to help believing that the blastopore primitively represented a mouth. It may perhaps have lost this function owing to an increase of food yolk in the ovum preventing its being possible for the blastopore to develop directly into a mouth, and necessitating the formation of a fresh mouth. If such were the case, there would be no reason why the blastopore should ever again serve functionally as a mouth in the descendants of the animal which developed this fresh mouth.

On the Anatomy *of the* Border *of the* Posterior Elastic Lamina *of the* Cornea, *in relation to the* Fibrous Tissue *of the* Ligamentum Iridis Pectinatum. By John Denis Macdonald, M.D., F.R.S., Deputy-Inspector General, R.N.; Assistant-Professor of Naval Hygiene, Army Medical School, Netley. (With Plate XI.)

On dissecting the human eye with the view of demonstrating the generally admitted metamorphosis of the whole border of the *posterior elastic lamina* of the cornea into the fibrous tissue from which the little tendons of the *ligamentum iridis pectinatum* arise, I was surprised to find that no such transformation was anywhere to be detected. The two structures, though, indeed, associated in a very intimate and peculiar manner, were nevertheless, perfectly distinct and not to be confounded with one another. This discovery led me to examine the eye of the sheep more minutely in reference to the point in question, as the pillars of the iris in that animal are very distinctly marked, being much less crowded than they are even in the ox. The result of the investigation may be simply stated as follows:

The peripheral tendon-like processes of the pectinated ligament (Fig. 1 and 2 c) were observed to perforate the border, divide dichotomously (e), intercommunicate (f), and break up, on its anterior surface, into a beautiful fibrous plexus (g) with a disposition of its elements in a concentric rather than in a radial direction.

Moreover, the little tendons, on entering the lamina, were enveloped by conical extensions of structureless substance (d), more strikingly resembling a coating of vitreous enamel than the tubular reflections of a membrane as ordinarily understood. I have taken the following extract from Kölliker's 'Microscopic Anatomy' (p. 541), as affording a good statement of the present acceptation of the structure of the parts here concerned in the human subject, and how far my own observations on the eye of the sheep and ox are at variance with it will be seen at a glance.

"The thickness of *Descemet's* membrane" (posterior elastic lamina) "amounts to 0·06‴ to 0·08‴, and towards the borders of the cornea it passes into a peculiar system of fibres, which were first observed by *Reichert*, and described more at length by *Bowman*. This system of fibres commences at a small distance from the border of the cornea at the anterior surface of Descemet's membrane, and first forms an elongated network of fine fibrillæ, like fine elastic fibrils; these then become gradually denser till, at the border of the cornea itself, Descemet's membrane has broken up in its entire thickness into a network of thick fibres and trabeculæ, which divides into three portions. The one part turns round in the whole circumference of the anterior chamber of the eye in the form of numerous processes which pass freely through this chamber upon the anterior border of the iris; these constitute the *lig. iridis pectinatum*, and coalesce with the anterior part of this structure. Another portion passes into the ciliary ligament, or rather into the musculus ciliaris; and the remainder of the network prolonged from *Descemet's* membrane is lost in the inner wall of the canal of *Schlemm*."

From the facts already mentioned it is clear that the membrane of *Descemet*, though much reduced in thickness, is traceable beyond the marginal pectinations of the iris into the *outer* wall of the canal of *Schlemm*. Indeed it may be fairly inferred that the delicate lining of the inner wall of that canal is an extension of the same coat, after having passed in front of the ciliary ligament. This would carry the basement of the membrane of the aqueous humour farther than is at present admitted; and to continue a similar line of argument, as the conical tubular processes arising within the margin of the posterior elastic lamina, visibly invest the pectinations of the iris, and a fine plexus of the same nature immediately behind them, to a very considerable extent, it would not be unreasonable to assume that they are in continuity with the delicate but unequivocal tunic of the iris itself.

The membrane of the aqueous humour was formerly represented as lining the walls of the anterior and posterior chambers of the eye throughout. But a doubt has of late been cast upon this view, and the whole extent of the membrane in question is now supposed to be simply commensurate with the posterior surface of the cornea, upon which part alone a distinct epithelial coat is said to be found. According to this, the posterior elastic lamina is the true basement of the restricted membrane of the aqueous humour, and the disease previously known as aquo-capsulitis must receive a new signification. The foregoing facts and considerations, however, seem to me to be rather in favour of the former doctrine, added to which it is further known that the iris also is covered with a fine epithelium. Thus, besides the three coats and three humours, three structureless capsules appertaining to the latter may be recognised in the eye as of old. But to return from this apparent digression to the more immediate subject of the paper, I must state that much difference of opinion still exists amongst histologists as to the real nature of the fibrous tissue which is said to originate in a transformation of the border of *Descemet's* membrane in its entire thickness. I am led to think, however, that the conflicting views on this subject will be reconciled when it is known that the tissue alluded to carries with it, as it were, a glaze or delicate coating of the homogeneous hyaline material of which the elastic lamina itself is composed (this is of course quite distinct from the epithelium which, unless detached during the process of examination, is found coating the structure). Indeed, this must have been observed by Mr. Bowman, who, from the appearances presented to him, drew the very rational and natural deductions embodied in the quotation from Kölliker above made.

The attachment of the posterior elastic lamina to the cornea proper can scarcely be said to be very intimate. On the contrary, it is quite easily detached, if not as a whole, at least in shreds. Its tendency to roll up in the direction of its convexity is doubtless one of the means by which its contact with the cornea is preserved. But if, in accordance with existing views, the whole or a considerable part of the contractility of the iris and ciliary muscles were to be brought directly to bear upon the border of the elastic lamina, it is easy to conceive that a hitherto unthought-of class of lesions would be frequently witnessed by ophthalmic surgeons. By the beautiful mechanism pointed out in this paper, however, nature has provided against the possible occurrence of such lesions, and thus, while the border of *Descemet's* membrane is pinned down, so to speak, to the fibrous cornea, forcible traction is communicated to this latter structure chiefly, and not to the elastic membrane alone. If there is no fallacy in this reasoning, or in the interpretation of the facts upon which it is founded, a more striking instance of design, or as some would have it, adaptive direction of force, does not exist, in an organ so abounding in wonders as the eye.

On the Pathology *of* Sheep-pox.[1] By Dr. Klein, F.R.S., Assistant Professor in the Brown Institution Laboratory.

Variola ovina, or sheep-pox, is a disease which, although it is not communicable to man, and possesses a specific contagium of its own, very closely resembles human smallpox, both as regards the development of the morbid process and the anatomical lesions which accompany it. This correspondence is so complete that it cannot be doubted that the pathogeny of the two diseases is the same. That is to say, that whatever explanation can be given of the way in which the material cause or contagium produces its effects in the one case will also serve as a key to the understanding of the other. The present investigation was therefore undertaken in the confidence that the application of the experimental method to the investigation of the ovine disease would not only yield results of value, as contributory to our knowledge of the infective process in general, but would throw special light on the pathology of smallpox.

In the following pages I propose, after giving an account of the method of investigation employed, to describe, first, the microscopical character of the sheep-pox virus, and to compare them with those of vaccine lymph. I shall then proceed to detail the results of my investigation of the pathological changes which occur in the affected parts of the skin.

Section I.—*Method of Investigation.*

The purpose of the inquiry being to determine the nature of the pathological process, of which the cutaneous eruption is the most prominent, and probably the most important manifestation, it was necessary to examine the affected skin anatomically in all stages of the development of the disease. In order to obtain the material for this investigation, I communicated the disease by inoculation to a sufficient number of sheep. In this way I obtained specimens of skin, corre-

[1] Reprinted from the 'Reports of the Medical Officer of the Privy Council and Local Government Board,' New Series, No. 3, by permission of the Lord President of the Council and of H.M. Stationery Office.

sponding to each successive period in the development of the pustule, which had been removed from the animal in a perfectly fresh state. With the aid of the complete and continuous series of preparations of which I thus became possessed, I was enabled to study the process in a most satisfactory manner.

The lymph used for inoculation was obtained from two sources, one quantity having been sent to me by Professor Chauveau, of Lyons, the second by Professor Cohn, of Breslau. In some of the inoculations the lymph was first diluted with from fifteen to twenty times its volume of half per cent. solution of common salt; in others it was used undiluted. No difference was observed as regards the results between the diluted and undiluted liquids; in all cases the instrument employed for insertion was a Pravaz syringe.

A drop having been drawn into the steel canula of the instrument (the width of which does not exceed the fortieth of an inch), it was passed under the surface of the skin, as in subcutaneous injection. In order to avoid bleeding, great care was taken to direct the needle in such a way that it penetrated the true skin as little as possible. Before discharging it the canula was always slightly drawn back, so as to leave the channel previously made by its point free for the reception of the expelled liquid. It will be understood that in using a subcutaneous syringe for inoculation in the manner above described, the only part of the instrument which is occupied by the liquid to be inserted is the extremity of the steel tube; the extremely small quantity of liquid which is thus employed is ejected at the desired moment by the compression of the air behind it.

Although there can be no doubt that the nature of the pathological process in the skin is the same whether it is determined by the direct insertion of the virus into the affected part, or is conveyed to it by the circulation, yet it appeared clear that the value of the results would be impaired if the investigation extended only to the local effects produced by inoculation. I therefore felt it to be very desirable (considering it was out of the question to obtain opportunities of studying the disease as it occurs naturally) to induce it in a form resembling the natural one as closely as possible.

Natural sheep-pox, as acquired by the ordinary modes of infection, is characterised by a general eruption, the first appearance of which is accompanied by an accession of fever.

I had not only learned from my own observation that no general eruption could be induced by inoculation, but found, on referring to authorities, that in those countries in which inoculation is carried on on a very large scale with a view to the protection of animals from attacks of the disease, it is extremely rare to meet with instances in which secondary pustules present themselves in addition to the primary one at the seat of insertion; it was therefore necessary to employ some other method.

I fortunately succeeded completely in producing a general eruption by introducing the sheep-pox virus into the circulating blood. Having diluted the liquid with from fifteen to twenty times its bulk of the solution of chloride of sodium already referred to, I injected it directly into the external mammary vein of a healthy sheep. At the same time that this was done I inoculated the animal in the usual way, making in all ten insertions. My object in employing both methods simultaneously was, that I might utilise the animal to the utmost. I was desirous on the one hand to induce a general infection, and thereby a general eruption; and on the other to obtain an additional supply of primary pustules for the completion of the investigations I had already made. I also thought it of great importance to compare the anatomical characters of the primary and secondary eruptions in the same animal.

The injection and inoculation were performed on the 1st of April; the primary papules made their first appearance on the 4th. On the 7th several small secondary papules appeared on the lips and around the mouth, and increased rapidly in number during the succeeding three days. At the same time the eruption extended to other parts of the body, but the papules were most numerous in the axilla and on the belly. It is to be noted that the interval of time between the appearance of the first and last papules of the secondary eruption was considerable, so much so that the pustules on the lips had already formed crusts at the time that the eruption was first visible in other parts. In this case, as in the others, the primary pustules were from half an inch to an inch and a half in diameter; most of the secondary ones did not exceed a quarter of an inch, but there were a few of those which appeared latest on the chest and belly which measured half an inch or more.

SECTION II.—*Microscopical characters of Sheep-pox virus.*[1]

Clear lymph, which had been kept for several days in a sealed capillary tube, was diluted with thoroughly boiled half per cent. saline solution. One portion of the diluted liquid having been reserved for further experimental inoculations,

[1] The description relates to a specimen of lymph sent by Prof. Cohn.

the remainder, which was intended for microscopical examination, was found to contain the structures represented in fig. 1.[1]

FIG. 1.

1. Transparent masses of various sizes, containing granules, some of which are small, pale, and indistinct, others large and shining.
2. Transparent spheroid bodies arranged in small groups composed of couples or necklace-like chains; each is bordered by a sharp line as if consisting of transparent contents enclosed by a membrane.
3. Highly refractive micrococci grouped so as to form dumb-bells or sarcinæ or small colonies.
4. Groups of decolorized blood-corpuscles, with micrococci occupying the interstices between them.
5. Bacteria, of which the smaller ones correspond to *Bact. termo* of Cohn.
6. Colonies of *Bacterium termo*.
7. Micrococci mostly in couples or in small groups. Each spheroid is surrounded by a greenish envelope, or in some cases by what appears to be a thin membrane; the couples, in consequence of their being united by a transparent connecting substance, resemble rods with terminal swellings; these bodies are about twice the size of the micrococci referred to above.
8. Groups consisting of spheroids of two kinds, the larger corresponding with (2), the smaller with (3); on careful examination it is found that between the two kinds of bodies there are transitional forms, of which the characters are intermediate both as regards size and

[1] The reference numbers on the figure correspond to those of the paragraphs.

appearance. These groups appear to correspond to those figured by Cohn as microsphæra vaccinæ.

In the same preparation after it had been kept at the temperature of incubation for 24 hours, the transparent masses referred to above (1), were found to have undergone the remarkable changes shown in fig. 2.

FIG. 2.

Under a high power it is seen that they consist of spherical granules of different sizes arranged in rows, each granule being united to its successor by pale transparent substance, so that the whole appears to be made up of a feltwork of delicate granular filaments, among which separate granules are seen here and there. In preparations kept for 48 hours the larger masses are seen to have broken up into smaller ones, in which the individual fibrils can be more easily traced, while the granules themselves have assumed characters which correspond to those of the micrococci (3), and pale spheroids (2) seen in the fresh lymph. This conversion of the granules contained in the masses into spheroids and micrococci, goes on for some days, so that these bodies multiply very considerably in the liquid.

Examination of perfectly recent Lymph.

A drop of lymph obtained on March 24th from a pustule of an animal that had been inoculated March 10th was examined microscopically without dilution, and was found to contain, in addition to granular pus-corpuscles and coloured blood-corpuscles, numerous small highly refractive granules, either isolated or in couples, which exhibited molecular movement. After having been kept at 32° C. for 27 hours, it exhibited the following structures (fig. 3) in addition to those already mentioned:—

[1]1. Pus-corpuscles, of which the substance has become swollen and transparent, each containing from two to six homogeneous slightly refractive spheroids. These

[1] The numbering of the paragraphs corresponds as before to that of the Fig. (3).

bodies, of which the diameter is less than half that of a coloured blood-corpuscle, are also seen in consider-

Fig. 3.

able numbers in the free state; they possess a slightly greenish colour, and are perfectly homogeneous, differing in both of these respects from nuclei of pus-corpuscles. When not enclosed in pus-corpuscles they occur either isolated or in couples; in form they are usually spheroidal, but are occasionally oblong, showing a more or less marked constriction in the middle. Along with these, other forms exist, in which it can be made out that the body, if a spheroid, consists of a highly refractive smaller granule (micrococcus) contained in a transparent envelope; or if oval or rod-like, of two such granules held together in a similar manner. Between these and the free micrococci to be immediately described, it is easy to observe the transition.

2. By the repeated division of the spheroids above described, the dumb-bells and necklaces shown in the figure[1] are formed; the constituent micrococci of the necklaces are held together by a connecting transparent substance. Sometimes they are all of the same size, but more frequently one is larger than the rest, and presents the appearance of a greenish transparent pear-shaped body, which may or may not contain a

[1] The particles forming the necklaces present the appearance of solid bodies; this is not well shown in the engraving.

highly refractive granule. The necklaces, which have grown to a great length and have become much convoluted, are apt to break up into shorter chains, forming

3. Groups from which the free ends of the filaments project. By the coalescence of these groups of convoluted chains, colonies, consisting of micrococci closely packed together, are produced, which correspond in appearance to the Zooglæa of Cohn; these colonies are often connected together by

4. Long filaments, some of which still show a necklace-like structure, while others are apparently smooth and homogeneous. Twenty-four hours later the colonies were found to have increased in number and size; some of the individual micrococci had also undergone changes, having not only acquired larger dimensions, but having assumed the appearance represented in Fig. 1 (7).

From the appearance above described I conclude that the highly refractive spheroid is the only form that can be regarded as characteristic of the lymph of sheep-pox in its active condition.

SECTION III.—*Anatomical Investigation of the Changes which occur at the Seat of Inoculation.*

1. The development of the primary pock may be divided into three stages, of which the first is characterised by progressive thickening of the integument over a rapidly increasing but well-defined area; the second, by the formation in the rete Malpighii of vesicular cavities containing clear liquid (the "cells" of older authors), in which sooner or later organic vegetable forms are developed; the third, by the impletion of these cavities with pus-corpuscles. It is to be noted that the division into stages is less marked than in human smallpox.

2. The process commences in the rete Malpighii and in the subjacent papillary layer of the corium—in the former, by the enlargement and increased distinctness of outline of the cells, and by corresponding germinative changes in their nuclei; in the latter, by the increase of size of the papillæ, and by germination of the endothelial elements of the capillary blood-vessels.

3. It is next seen that the interfascicular channels (lymphatic canaliculi) of the corium are dilated and more distinct; that the lining cells of these channels are enlarged and more

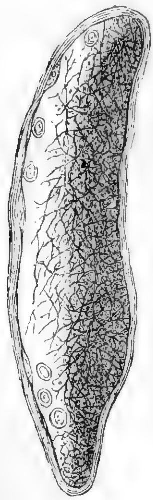
easily recognised than in the natural state; and that in the more vascular parts of the corium the channels are more or less filled with migratory or lymph-corpuscles. At the same time, the lymphatic vessels, of which the canaliculi are tributaries, can be readily traced, in consequence of their being distended with a material which resembles coagulated plasma.

FIG. 4.

4. About the third day after the appearance of the pock the contents of the dilated lymphatics begin to exhibit characters which are not met with in ordinary exudative processes. These consist in the appearance in the granular material already mentioned, of organized bodies, which neither belong to the tissue nor are referable to any anatomical type—viz. of spheroidal or ovoid bodies having the characters of micrococci and of branched filaments. In fig. 4 a lymphatic vessel of the corium is seen in section filled more or less completely with micrococci. In some parts the spheroids are aggregated in the zooglæa form, so that the mass appears granular, in others it presents a filamentous aspect, the spheroids being in necklaces or chaplets. In the upper part of the figure a blood-vessel (*c*) is shown in section which is sheathed in the lymphatic channel, at (*d*) a valve is shown with masses of micrococci on either side of it; (*bb*) indicate interfascicular channels containing connective-tissue corpuscles. In fig. 5 a similar lymphatic vessel of the corium

Fig. 5.

Fig. 6.



is represented, of which the contents have the characters of a mycelium, and consist of branched filaments. In fig. 6 the same structure is seen, but the interlacing of the filaments is so dense that the whole presents the aspect of a felt-like mass.

5. The process thus commenced makes rapid progress. After one or two days the greater number of the lymphatics of the affected part of the corium become filled with the vegetation above described; and on careful examination of the masses it is seen that they present the characters of a mycelium, from which necklace-like terminal filaments spring, each of which breaks off at its free end into conidia. In most of the filaments a jointed structure can be made out, and in the larger ones the contents can be distinguished from the enclosing membrane by their yellowish-green colour.

The necklace-like filaments are well seen in fig. 7. They are contained in a lymphatic vessel of the corium similar to those represented in figs. 4, 5, and 6.

Fig. 7.

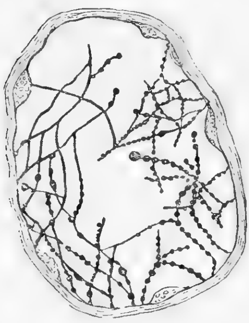


Fig. 8.

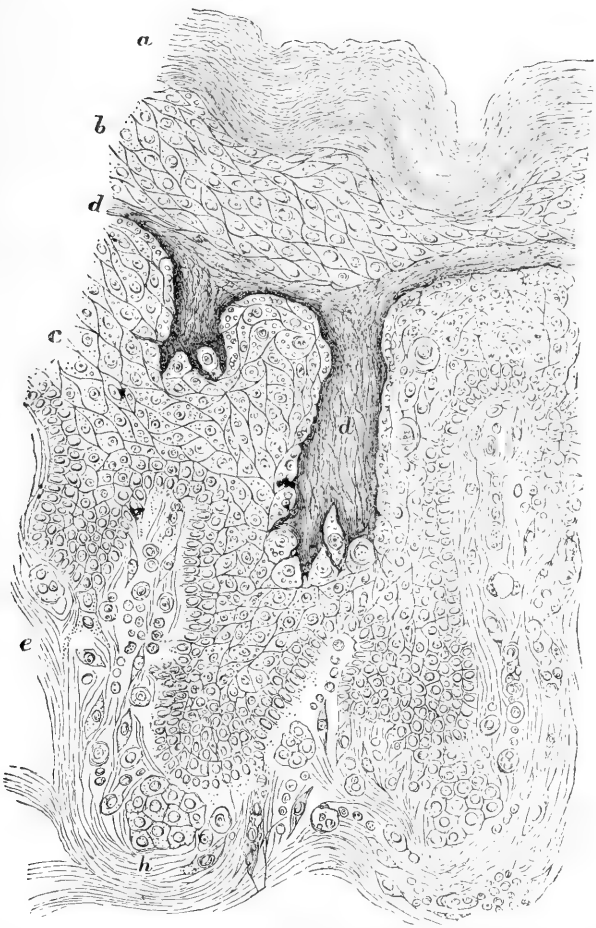
Separated conidia, in a state of germination, are shown in fig. 8, as seen under a much higher power.

6. At the same time that these appearances present themselves in the corium, those changes are beginning in the now much thickened rete Malpighii, which are preparatory to the formation of the vesicular cavities already mentioned. By a process which I propose to designate horny transformation, having its seat in the epithelial cells of the middle layer of the rete Malpighii, a horny expansion or stratum appears, lying in a plane parallel to the surface, by which the rete Malpighii is divided into two parts, of which one is more superficial, the other deeper than the horny layer. Simultaneously with the formation of the horny layer the cells of the rete nearest the surface of the corium undergo very active

germination, in consequence of which the interpapillary processes not only enlarge, but intrude in an irregular manner into the subjacent corium. At the same time, the cells immediately below the horny stratum begin to take part in the formation of the vesicular cavities, some of them enlarging into vesicles, while others become flattened and scaly, so as to form the septa by which the vesicular cavities are separated from each other.

The whole of this process is well shown in fig 9,[1] which

Fig. 9.



[1] (*a*) Stratum corneum, (*b*) superficial layer of *rete Malpighii*, (*c*) deep

represents a vertical section through the central portion of a primary pock on the eighth day.

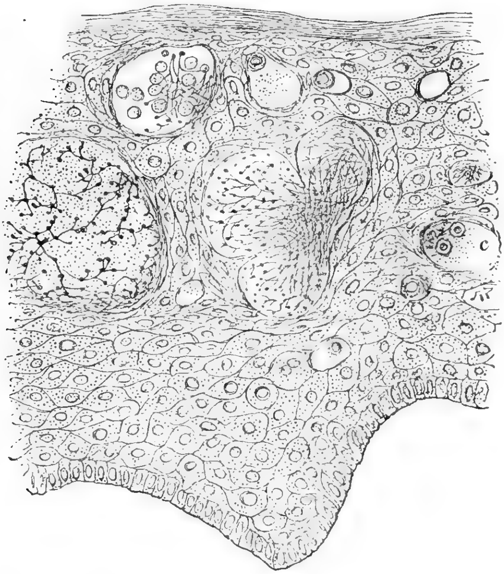
The stratum corneum is unaltered. The newly formed horny layer by which the rete Malpighii is abnormally split into a superficial and a deep layer, is seen to be formed by the transformation of the cells which lie next to it on its superficial aspect. On its deep surface are cells which are much enlarged and contain vacuoles; they present the appearance to which pathological histologists frequently apply the term dropsical. It is by the subsequent dilatation of these enlarged cells that the vesicular cavities ("cell" of the older authors) are formed; between them the septa are seen composed of flattened and scaly cells which, as above described, extend from the horny layer towards the interpapillary processes. The drawing further shows the remarkable changes which take place in the papillary processes themselves simultaneously with the formation of the horny layer. In consequence of the very active germination of the cells of which these processes consist, they send down conical or cylindrical sprouts into the corium; it sometimes happens that the end of one of these sprouts is cut off, so that it presents itself in the section as an island of cells (*h*) surrounded by the tissue of the corium.

7. The vesicles, once formed, increase in size and number. Originally separate, and containing only clear liquid, they coalesce, as they get larger, into irregular sinuses, and are then seen to contain masses of vegetation similar to those which have been already described in the lymphatic system of the corium—with this difference, that the filaments of which the masses are composed are of such extreme tenuity, and the conidia are so small and numerous, that the whole possesses the characters of zooglæa rather than of mycelium. There appears to me to be little doubt that these aggregations are produced in the same way as the others, viz., by the detachment of conidia from the ends of filaments. The characters of the vegetation contained in the vesicular cavities are well shown in fig. 10. The contents of a single vesicle, as seen under a much higher power, are represented in fig. 11. In the earlier stages of the process the cavities contain scarcely any young cells. Sooner or later, however, so much of the rete Malpighii as lies between the horny stratum and the papillæ becomes infiltrated with migratory lymph-corpuscles. The process can be plainly traced in the sections. At the period of vesiculation, *i. e.* at a time corresponding to

layer of do., (*d*) newly formed horny layer, (*e*) superficial or papillary layer of corium.

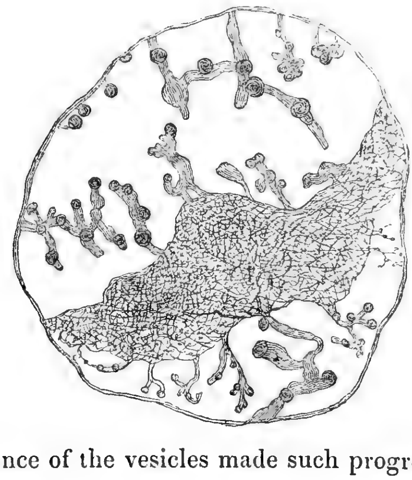
the commencement of the development of the vesicles in the rete Malpighii, the cutis (particularly towards the periphery

FIG. 10.



of the pock) is infiltrated with these bodies. No sooner has

FIG. 11.



the coalescence of the vesicles made such progress as to give rise to the formation of a system of intercommunicating sinuses, than it is seen that the whole of the deep layers of the rete Malpighii become inundated (so to speak) with migratory cells, which soon find their way towards the cavities, and convert them into microscopical collections of pus-corpuscles, the formation of which is proved to be due to migration from the corium, not only by the actual observation of numerous amœboid cells *in transitu*, but by the fact that the corium itself, before so crowded with these bodies, becomes, as the pustulation advances, entirely free from them.

Section IV.—*Anatomical Investigation of the General Eruption.*

The anatomical characters of the secondary pocks are substantially the same as those of the primary, the most prominent features being thickening of the rete Malpighii and œdema of the corium, combined with the presence of lymph-corpuscles around the blood-vessels, with similar corpuscular infiltration of the lymphatic canalicular system in the neighbourhood.

In general the stage of pustulation is reached more rapidly in the secondary pustules than in those which are the direct result of inoculation. Thus, in the eruption on the lips the contents of the vesicular cavities became purulent not later than the third or fourth day; after the appearance of papules on the chest the development was more tardy. The infiltration of the cutis and papillary tissue was greater towards the periphery than towards the centre, especially in those pustules that had lasted longest and exhibited most distinctly a central depression. There were also considerable differences as regards the changes which, in the primary pustule, result in the splitting of the rete Malpighii into two layers. The peculiar transformation which in the primary pustule goes on to such an extent as to result in the formation of a horny layer, which is of such thickness and so well marked that it can be distinguished in the section by the naked eye, is represented in the secondary pustules by a change of the same kind, which, however, is very partial in its extent and distribution, and affects only a few cells of the middle layer of the rete. Connected with this there is a considerable difference in the mode of the formation and the arrangement of the vesicular cavities. They appear in great number simultaneously in the middle layers of the rete Malpighii, and are generally found much nearer the corium than in the primary pocks. It is further to be noticed as a collateral fact that in consequence of the number and progressive dilatation of the vesicles at the expense of the deepest layers of the rete, the inter-papillary processes become obliterated, so that the corium is marked off from the rete by a line which is almost as even as it is in sections of the natural skin. As a further result of the distinction of the vesicles, it is sometimes seen that the deepest cells of the rete are altered in form by compression. As regards the distribution of the vesicles in the secondary pustule, it is to be noticed that even in those pocks that exhibited a marked central depression, the most numerous and well-developed vesicles were found towards the centre; this is clearly inconsistent with the supposition that the depression is caused by the disappearance of previously existing vesicles.

As has been already stated, the vegetations contained in the lymphatics of the corium, as well as those occupying the vesicular cavities, presented the same characters as those which have been already described in the previous section. In some vesicles the mycelium is imbedded in a finely granular matrix, which is to be regarded as coagulated plasma; in others the matrix is almost homogeneous, and is stained slightly by carmine and hæmatoxyline. The mycelium itself, as well as the spores which devolve from it, exhibit a bright and shining appearance. Eventually the mycelium is transformed by a process of rapid fructification into a mass of micrococcus resembling zooglæa, the characters of which are not to be distinguished from those of the similar masses which are met with in the primary pustules when examined at a later stage of their development.

On a New Peritrichous Infusorian (*Cyclochæta spongillæ*). By Wm. Hatchett Jackson, B.A., F.L.S., Demonstrator of Anatomy, University Museum, Oxford. With Plate XII.

The Infusorian figured Pl. XII was originally found by my friend Mr. W. H. Poole, of Magdalen College, while engaged in examining a fine fresh-water sponge (Spongilla fluviatilis) taken from the river Cherwell. He was good enough to give me the first specimen as well as another he found subsequently. These two, together with others obtained by myself from the same sponge, form the subject-matter of the present paper.

This Infusorian belongs to a remarkably interesting type, and appears to be a genus altogether new and hitherto undescribed. It was happily in my power to make a very complete and prolonged examination of structural details in many specimens; the results thus acquired I will now proceed to state as fully as possible, and then say a few words on the affinities and position of this organism.

All the examples found by Mr. Poole and myself were obtained by tearing up small portions of sponge on a glass slide and then hunting about among the fragments under a microscope. When a fresh-water sponge is broken across, the internal substance is seen to be of a whitish hue and surrounded by an outer (cortical) green layer. From this green layer came all my specimens. None could be obtained from the water in which the sponge lay, though portions were repeatedly taken up by a pipette close to the sponge itself and from other parts of the can in which we kept it. Hence it seems that our Infusorian may justly be regarded as ecto-parasitic, probably living on the surface or in the more superficial layers of the sponge substance.

As to size, the animal is quite invisible to the naked eye, but may easily be made out with a No. 4 object glass and ocular 2 (Hartnack). The figures on Pl. XII were drawn under a No. 8 object glass with ocular 2 quadrillé, the details being further worked out under the same object glass with ocular 4 and the tube drawn out. The body measures from $\frac{1}{416}$ to $\frac{1}{420}$ of an inch in transverse diameter; while from the tips of the cilia on the one side to those on the other the measurements varied from $\frac{1}{277}$ to $\frac{1}{280}$ of an inch.

As seen when slowly moving on the under surface of the thin cover-glass it shows a central disc fringed externally by a circle of cilia—a striated border and a peculiar apparatus of hooks borne by a ring composed of a substance altogether different from the rest of the animal, supported by processes running inwards towards the centre of the disc. This centre is a deep cup-shaped hollow, limited by a hyaline wall through which are visible granules, vacuoles, nucleus, and ciliated pharynx. The basal portion of the ciliary fringe is partially obscured by a clear border with a few granules in it. This view is represented in fig. 1. But when the animal quits the cover-glass and swims, as it does very rapidly, to a piece of sponge-substance, the side view has the appearance shown in fig. 2. This is the natural position when swimming, the animal invariably moving with the disc turned forwards. It can now be seen to have, attached to one surface of its disc, a somewhat flattened and roundish mass of protoplasm,—the body,—in which are lodged pharynx, vacuoles, and nucleus, the mouth being situated in the body at its junction with the disc. The animal may therefore be conveniently described under the heads of (1) the disc and (2) the body.

1. The disc is of a very complex structure, presenting us with a central depression surrounded by the hooked ring, striated border with the fringe of motor cilia, while on its oral side a few long and slender setæ (s., fig. 2) are attached.

The motor cilia (c., figs. 1, 2, 6) are arranged in a complete circle on the margin of the striated border. They are stoutish, nearly of the same size from base to apex, and of a pale green colour, continuously in motion, undulations running round the disc even when the animal is stationary. They have on the oral surface and close to their bases a small nodule or boss (c^1., fig. 6), in colour and consistency exactly similar to the cilia themselves. This nodule may possibly be a rudiment of the velum described and figured by James Clark in *Trichodina pediculus*.[1]

Within the circle of motor cilia is the striated border (st. b., fig. 1 and 2 seen obliquely). This is composed of a perfectly clear substance, marked by fine striæ arranged radially. It does not appear to be rigid, but, as may be seen in fig. 1, varies in breadth. This variation is due apparently to different portions of it being placed simultaneously at various angles to the eye. In fact, when seen sideways, it could be perceived that this striated margin of the disc bent backwards and forewards with a slow undulating movement (cf. fig. 2). The striæ are on the anterior (*i.e.* aboral) surface of the disc. A superficial set could not be distinguished from a more deeply placed set, though such a distinction was found by James Clark in *T. pediculus*.[1] These striæ (fig. 1) are not quite regular, in some places seeming to be placed near together and then being fine, in others far apart and then coarse. At a spot where the cilia were moving the striated border appeared darkish and the striæ very near together (as *e.g.* on right side of fig. 1), so that probably the want of uniformity observed was really due to contractions in the substance of the disc itself and the consequent approach of the striæ to one another.

Next to the striated border and internally to it lies the

[1] 'Annals and Mag. Nat. Hist.,' 1866, p. 412, Pl. VIII, figs. 8, 10, 11, f^1, Pl. IX, fig. 17, f^1.

[2] Loc. cit., pp. 413, 414, Pl. IX, fig. 17, l^1, l^2, and l^4, l^5.

hooked ring (r., figs. 1, 2, 6) which so clearly approximates this Infusorian to *Trichodina*. Externally is a row of 27 hooks (h., figs. 1, 7) all curved in one direction and implanted by a broad base on the ring (r., fig. 7) from the inner side of which arise slender processes—the radii (r^1, fig. 7), gradually tapering to their extremities, somewhat of a sinuous figure, and equal in number to the hooks. These radii are imbedded in the substance of the animal. They pass inwards below the surface of the central depression into the body, as may be seen from a careful examination of figs. 2 and 6. All this apparatus is quite rigid, of a greenish colour, and composed of some peculiar substance, the ring seen under a high power being streaked in a direction parallel to its circumference, while both hooks and radii are perfectly clear. James Clark[1] gives to the hooks and radii of *T. pediculus* a very complex structure, but nothing similar could be detected in this animal. On the other hand, the ring is here more complex than the similar apparatus of *T.* (*Urceolaria*[2]) *mitra* and *Trichodinopsis*[3]), which are destitute of teeth but have an apparently twisted structure.

Of the central depression nothing much is to be said. It is cup-shaped (d., fig. 2) and is unchangeable in form. Its limiting wall is perfectly hyaline, as mentioned before.

On the oral side of the disc, *i. e.* behind the circle of motor cilia when the disc is turned towards the observer as in fig. 1, is the row of setæ (s., figs. 1, 2), if such a name is justifiable. In the front view (s., fig. 1) they can be seen projecting slightly beyond the ends of the motorial cilia. In number they are sixteen. They are long, thickish at the base (cf. fig. 2), then rapidly thinning out and becoming finer at their extremities than are the cilia. In substance they are slightly rigid, not so much so as to be absolutely immovable or incapable of moving to a certain extent. Once the animal moved them in such a manner that they were arranged in the front view radially and in a plane parallel to the surface of the disc, that is, nearly at right angles to the position in which they are drawn in fig. 2. They are exceedingly difficult to see—in fact invisible—until the mirror of the microscope is adjusted at the proper angle to the object. What their functions may be, is doubtful. The only other example of anything at all similar is furnished by the circlet of setæ or setæ-like cilia in *Halteria*, attached in this

[1] Loc. cit., pp. 4, 14, 15, Pl. IX, fig. 18.

[2] Stein, 'Organisation der Infusionsthiere,' Abth. II, 1867, p. 147.

[3] Claparède and Lachmann, Études, vol. i, Pl. IV, figs. 1, 2. Stein, loc. cit., Abth. II, p. 146.

case to the middle of the body. These appear to be capable of motion forwards or backwards, judging from the figures given by Claparède.[1] In our Infusorian the swift movements of the animal rendered these setæ quite invisible, and they could only be discerned when it was stationary, then assuming the position delineated in fig. 2.

2. The body (b., fig. 1, 2) is composed of a protoplasm, in which are imbedded minute greenish particles, possibly derived from the sponge. The outside edge of the protoplasm is free from granules (cf., fig. 6), perfectly transparent, and this is the only apparent differentiation of a body wall, there being not the slightest trace of the striæ so common in many Infusoria. This protoplasm is quite soft. The body slowly changes its shape in the most astonishing manner. In fig. 2 it is represented of the form it usually showed, but in one and the same individual it assumed successively the shapes drawn in figs. 3, 4, and 5. Whether this continual change of shape is or is not natural, it is impossible to say, perhaps being due to the effect of confinement. Similar confinement seems to affect *Trichodina pediculus* in much the same way.[2] The body is slightly larger than the disc, and consequently in the front view (fig. 1, b.) is seen surrounding the latter as a bright granulated border.

The mouth (m., figs. 2 and 6) is situated in the body at the spot where it may be considered as uniting with the disc. It is of a moderate size, and leads at once into a ciliated pharynx (ph., figs. 1, 2), which stretches far into the body tending away from the disc. Seen from the front (fig. 1) it appears to be ciliated on both sides, but when viewed sideways cilia were visible on that side alone which is turned towards the disc (cf. figs. 1 and 2, ph.). Hence it may perhaps be concluded that this side is flat and ciliated all over, the other walls of the pharynx being non-ciliate.

There was one vacuole (v., figs. 1, 2) constant in its position in all the specimens examined; filling and bursting with the greatest regularity. One or two others occasionally appeared (v^1., figs. 1, 2).

With the exception of one specimen there was invariably present a greenish body, elliptical in shape and placed in the same position, viz. to one side and at a deeper level than the pharynx, and small in size. This body I take to be the Endoplast (nucleus auctt.), as yet unripe. It was slightly granulated, but no other structure was detectible in it (n., figs. 1, 2). Acetic acid brought out no further details.

[1] Loc. cit., Pl. XIII, figs. 8, 9.
[2] James Clark, loc. cit., p. 405.

This Infusorian is evidently closely allied to the genus *Trichodina*. The presence of the hooked ring, the striated border, the complete circle of motor cilia, at once place it in the Peritrichous family—*Urceolarina* of Stein. All the members of this family infest certain animals. *T. pediculus* and *T. diplodiscus* are found on *Hydra*, the former also in the allantoid bladder of *Tritons*;[1] *T. Steinii*, on Planarians (?)[2]; *Urceolaria (T.) mitra* on Planaria torva, and *Trichodinopsis* on Cyclostoma elegans, and in the pulmonary chamber of the same Mollusc[3]. Whether this animal is or is not restricted to Spongilla cannot as present be positively stated.

The different genera and species of the family *Urceolarina* vary much among themselves. *Trichodinopsis* and *Urceolaria* have rings without hooks, but of an apparently twisted structure. The former is ciliated all over the body, though Stein[4] states that he found specimens in which this ciliary coat was wanting. *Trichodina* has the ring hooked.

But our Infusorian in certain points differs from all the other members of this family—(1) in the absence of the adoral spiral of cilia, the homologue of the ciliary spiral in the stalked *Vorticella;* and in the presence of a circle only of motor cilia, the homologue of the posterior circle of cilia in the free-swimming zooid of *Vorticella;* (2) in the presence of the long setæ (s.) which perhaps point to an affinity with Halteria, as mentioned above; (3) in the extreme softness of the body and (4) the very peculiar position of the mouth.

These points seem to me sufficient to warrant the establishment of a new genus, to which I should propose to give the generic name of *Cyclochæta*, in allusion to the setæ. This is a more striking peculiarity than the absence of the adoral spiral of cilia—a fact important, however, in the definition of the family, which ought to be modified—the two circles of cilia, buccal and motor, being usually present, though the buccal spiral is more feebly marked in *Trichodinopsis* than in *Trichodina*, and in this solitary instance of *Cyclochæta* has become obsolete.

Appended is the definition of the genus and a table of the characteristics of the genera in the family *Urceolarina*.

FAM. *Urceolarina.* Stein.

Cyclochæta. Animal with circle of setæ (16 in number) on

[1] Busch, 'Müller's Archiv,' 1855, p. 360, Taf. XIV, fig. 2.
[2] Claparède, loc. cit., vol. i, p. 130.
[3] Clap., vol. i, p. 132. Stein, loc. cit., Abth. II, p. 146.
[4] Stein, loc. cit., Abth. II, p. 146.

the oral surface of the disc; spiral of buccal cilia absent; mouth placed in the angle formed by the junction of the body and disc; body soft, changing in shape continually (?); ring with 37 hooks, and radii; being of one piece throughout.

Cyclochæta spongillæ; on the common fresh water sponge (Spongilla fluviatilis). River Cherwell, Oxford. August.

A. Animal provided with a spiral of buccal cilia.
  a. Ring not hooked; marked by a spiral line.
    1. Body ciliated—*Trichodinopsis*, 1 sp.
    2. Body naked; adoral spiral of cilia terminal—*Urceolaria*, 1 sp.
  β. Ring hooked; adoral spiral not terminal—*Trichodina.*
B. Spiral of buccal cilia wanting; animal furnished with a row of setæ behind disc—*Cyclochæta.*

Some Remarks *about the* Minute Anatomy *of* Mediterranean Nemerteans. By A. A. W. Hubrecht, of the Leyden Museum of Zoology. (With Plate XIII, figs. 6—8.)

A study of some fifteen different species of Nemerteans from the Bay of Naples at Dr. Dohrn's zoological station as well as an investigation of the scanty specimens inhabiting the Dutch coasts, have led me to results which have often confirmed, but which have not seldom differed from and contradicted the conclusions and views entertained by Mr. MacIntosh in his latest monographical treatises on the subject,[1] in which the British species are exclusively alluded to. It is these points of confirmation and criticism which I want to put together in the following lines, although they have been incorporated already in the more extensive description of my researches, published elsewhere.[2] In this brief extract I will follow the arrangement of Mr. MacIntosh's extensive treatise—yet without describing the Enopla and Anopla separately as is done there, comparing successively his principal observations with mine.

My observations extended for the greater part to species belonging to the anoplan genus *Meckelia*, viz. *Meckelia somatotomus* (Leuck.), *Meckelia* (Nemertes) *ligurica* (Blanch), *Meckelia Ehrenbergii* (Dies.), *Meckelia aurantiaca* (Grube), and further to *Polia delineata* (Delle Ch.), *Polia geniculata*

[1] 'Transactions of the Royal Society of Edinburgh,' 1869, and Ray Society's publications, 1873 and 1874.

[2] 'Aontecheningen over de Anatomie Histologie en Ontwikhelings geschiedenis vaneenige Nemertines,' Utrecht, 1874, and "Untersuchungen über Nemertinen," in Niederländisdisches 'Archiv für Zoölogie,' Bd. II, Heft 2, 1875.

(Delle Ch.), *Lineus longissimus* (Sowerby), *Lineus bilineatus* (Delle Ch.), and *Borlasia olivacea* (Thompson).

From the enoplan sub-division I had at my disposal several species of the genus *Ommatoplea* (Dies.), as well as three new species which I have put together in the genus *Drepanophorus* (n. g.) and which are distinguished by the structure of their stylet and stylet region differing entirely from the typical form found in all other Enopla. This curious deviation will be discussed in the proper place.

Dermal Tissues and Muscular Layers of the Body.

The difference existing with respect to these tissues between the enoplan and the anoplan forms (Mr. MacIntosh's Ommatopleans and Borlasians) is great indeed, showing that subdivision of the order (as first proposed by Max Schultze) to be a very natural one. Yet the principal investigators of the subject, such as Keferstein and Quatrefages, confounded the structures in the one with those in the other and it remained for Mr. MacIntosh to point out with great clearness the obvious differences. He reduces the number of muscular layers in the Enopla to an external circular one and an internal longitudinal one of greater thickness, and shows that the Anopla are, on the contrary, provided with an external as well as an internal longitudinal, with an interjacent circular layer. Keferstein's external circular layer is shown to be a structureless basement layer of the cutis. My observations tend fully to confirm these views. Many preparations of unarmed Meckelias had the external epidermic layer thickly provided with flask-shaped glands opening externally, which are mentioned by Keferstein, but about which Mr. MacIntosh is silent.

The interfascicular substance which plays so large a part in the structure of the body wall is rather undervalued by Mr. MacIntosh. It is a kind of fibrous connective tissue, surrounds the dermal structures, carries the pigment and forms layers between the cuticular and muscular layers corresponding to that separate basement layer, confounded by Keferstein with a muscular one. From this stratum numerous separate fibres can be traced entering into the interspaces between the fascicules of outer longitudinal muscles, continuing their way downwards through the circular and internal longitudinal layer, finally entering into the body-cavity, traversing this, and again completely piercing the opposite muscular body-wall, to find their way back into the dermal tissue.

Still the separate fibres of this fibro-elastic stroma do not penetrate at random into the body cavity, but mutually combine, giving rise to fibrous dissepiments (Pl. XIII, fig. 8) placed at regular intervals—one between each intestinal cœcum—and serving to attach and carry the intestine (*g*) and the small anastomotic blood-vessels (*e*). Moreover these vertical intercœcal septa are again composed of two separate layers lying close against each other in the normal condition and separating when the sexual organs begin to develop.

Eggs and spermsacs (*f*) take their origin between these layers. The fibrous septa might be regarded, on account of all these peculiar functions, as a kind of primitive mesentery.

Cavity of the Proboscidian Sheath.

Mr. MacIntosh was the first to recognise this cavity with its proper muscular wall and its characteristic corpusculated fluid as entirely separated from the general body-cavity with which it had been confounded by Keferstein and Quatrefages. This cavity, extending through the entire length of the animal, was present in all the species which came under my notice. The muscular wall, ordinarily attached to the dorsal side of the body-cavity, was exceedingly thick in *Drepanophorus* (n. gen.), being chiefly composed of circular fibres intermixed with longitudinal bundles. The inside was lined with elongated papillæ. This stronger development of the walls no doubt stands in connection with the great facility with which these species extrude their proboscides.

Proboscis.

The minute structure of this organ as described by Mr. MacIntosh could be verified in numerous specimens. In transverse sections of the proboscis of *Meckelia somatotomus* (Leuck.), the curious deviation of fibres from the internal and external circular muscular layers presented a somewhat different aspect, the mutual interchange of fibres not taking place on one side only, but on two diametrically opposed points.

With respect to the anatomical structure of the armed proboscis, my conclusions, are chiefly based upon the different species of Drepanophorus (n. g.)[1]

Mr. MacIntosh distinguishes six different layers in the anterior part of the enoplan proboscis, and for the first time mentions the presence of a separate layer with rather a puzzling character (his reticulated or beaded layer), enclosed

[1] For more details about this genus, *vide* Niederl., 'Archiv für Zoölogie,' Bd. II, Heft 2.

between the longitudinal muscular ones. This layer is very conspicuous in the *Drepanophorus* species, and consists of longitudinal columns, surrounded and united by bands of fibrous elastic tissue which at the same time traverse the longitudinal muscular coat in all directions, and originally depart from the external and internal circular layers of elastic tissue. (Plate XIII, fig. 6.)

These columns seem to consist of a very homogeneous tissue, no cut ends of fibres being visible in vertical sections, and carmine solution, which was strongly imbibed by the elastic tissue, never tinged them in the least. The curious flask-shape of these columns in vertical sections at first led me into the error of regarding this layer as a complex of small glands.

I am much in doubt as to the muscular character of the circular layers *e f*, and *i f*, which are held as such by Mr. MacIntosh. The longitudinal layer *l m*, is decidedly muscular, traversed by a meshwork of interlaced elastic tissue as remarked above. Neither do I wish to follow Mr. MacIntosh in regarding the external and internal portions of this layer as two distinct muscular coats.

Externally this part of the proboscis, when extruded, is covered with *thickly-set papillæ*, which are composed of fine translucent rods sticking together. They produce a gelatinous mucus, and render the proboscis in a high degree sticky. A separate papilla is figured, Plate XIII, fig. 7.

The structure of the stylet region, central and lateral stylets, is treated *in extenso* by Mr. MacIntosh. I only wish to point out the curious difference existing in this respect between *Drepanophorus* (n. gen.) and all other *Nemerteans* hitherto known. Instead of the usual transparent, straight, central stylet, with its swollen base and the peculiar muscular arrangement surrounding it, these species carry a crooked, dark-brown hook, pointed at the anterior, blunt at the posterior end, and held in position by a ring-shaped internal elevation of the proboscidean wall. A special muscular development in this region and natural stylet sacs are totally absent, a reservoir filled with a greenish fluid as well as traces of an ejaculatory duct being visible.

Something analogous was very vaguely described by M. De Quatrefages for his *Cerebratulus spectabilis,* but neither Max Schultze nor Mr. MacIntosh (who incorporates the species in his genus *Amphiporus*) believed in the correctness of the observations. The finding of three new species presenting a nearly similar stylet-shape confirms the validity of M. De Quatrefages' statements.

Digestive and Circulatory System.

In accordance with Mr. MacIntosh's statements I found the mouth in the Enopla situated *before* the ganglia, ventrally, a little behind the opening for the proboscis. In *Meckelia somatotomus* the ciliated œsophagus is distinct from the subsequent part of the digestive cavity in which the cœcal appendages appear. The œsophagus is further provided with very thick glandular walls. In *Drephanophorus* it is, on the contrary, very short, provided with thick glandular walls even before the ganglia, whilst the regular cœcal appendages make their appearance at no great distance behind these.

The circulatory system in *Drepanophorus* shows many points of resemblance with the same apparatus in *Borlasia splendida* (Amphiporus spectabilis, McInt.) as described by Keferstein. Besides the three longitudinal vessels a great number of anastomotic vessels, perpendicular to the first, occur, one in each intercœcal space. The contained fluid carries numerous red blood-corpuscles, which proved upon examination with the spectroscope to owe their colouring to hæmoglobin. This fact was already ascertained for *Polia sanguirubra* by Mr. Ray Lankester.[1]

For the larger Borlasian forms, such as *Meckelia somatotomus* (Leuck.), *Polia geniculata* (Delle Ch.), whose dark pigmentation prevents their being studied under compression, I could ascertain in longitudinal sections that here two fine anastomotic vessels—one for every intercoccal space—unite the dorsal vessel with the two lateral ones.

As to *Meckelia somatotomus* (Leuck.), Cerebratulus marginatus (Kef.), my observations confirm those of Mr. MacIntosh, who found in this species the vessels in their ordinary place, close to the nerve-trunks, thus contradicting Keferstein's statements on this point. I cannot, however, agree with Mr. MacIntosh in regarding the position of these blood-vessels in the Borlasians as quite constant. *Polia geniculata*, for example, carries its lateral vessels nearly in the middle of the body cavity, suspended by connective tissue under the intestine.

Nervous System.

The difference which exists between Enopla and Anopla in respect to shape and position of the ganglia and nerve-trunks was already pointed out by preceding investigators, and clearly stated by Mr. MacIntosh. A corresponding differ-

[1] 'Proceedings of the Royal Society,' No. 140, 1873.

ence in the cephalic sacs (Keferstein's side organs) probably goes alon with this, as I will further on endeavour to show.

[illegible] ly the ganglia are of a red colour, paler in the *Ommatopleans*, much deeper and richer in the large enoplan forms, such as *Meckelia somatotomus*, *Meckelia Ehrenberg.*, &c. To the kindness of Mr. Ray Lankester, then also at the Zoological Station, I am indebted for the use of his excellent microspectroscope, which, applied to the diffused colouring matter of these nerve-centres, left no doubts about its chemical constitution. It showed the two absorption-bands of oxyhæmoglobin with great distinctness. Mr. Lankester had found a few years ago hæmoglobin in the ventral nerve-chain of *Aphrodita,* and the curious fact of its occurrence in nerve tissue now stands isolated no longer. It must be observed that in the same species which showed this so strongly the blood was quite colourless and devoid of corpuscles, which are tinged by hæmoglobin in some other Nemertean species, as mentioned above.

Investigations into the minute histological structure of the four lobes of the ganglion, soldered together in front by the superior and inferior commissures, show that a thick bundle of exquisitely fine fibres occupies the middle of each lobe. A thick layer of nerve-cells surrounds this kind of axis on all sides. These nerve-cells are imbedded in a neurilemma-sheath, as described by Leydig[1], and vary in size. The smaller ones are the more numerous, still the larger ones occur very regularly, often attaining a diameter of 66 mm.

The central fibrous bundles of each of the four ganglionic lobes unite in the commissures, forming a closed ring. Those of the inferior lobes continue their course backwards in the nerve-trunks, those of the superior lobes *penetrate without interruption into the tissue of the cephalic sacs*, which lie behind these lobes in immediate contact with them, ending there.

The lateral nerve-trunks, whose different position in the Borlasians and in the Ommatopleans has been clearly pointed out by Mr. MacIntosh, show two different constituent elements, viz., (1) the above-mentioned central bundle of fibres, and (2) *a sheath of nerve-cells*, thicker in the vicinity of the ganglia, thinner further backwards, but accompanying the trunk in its entire length. The size of the nerve-cells agrees with that of the smaller cells in the central ganglia. Mr. MacIntosh has not remarked this cellular coating. He speaks of a fibro-granular matrix of a reddish hue enclosing the nerve-trunks. The red colour is caused by these nerve-

[1] 'Vom Bau des thierischen Körpers,' p. 86.

cells being like those of the ganglia, tinged with hæmoglobin.

In Drepanophorus (n. gen.) the position of the nerve-trunks reminds one of the genus Oerstedia (Quatref.), as they lie against the ventral wall of the body cavity, and have considerably approached the median axis of the animal. The statement of Mr. MacIntosh as to the position of the nerve-trunks in the Meckelian type, viz., between the circular and the inner longitudinal muscular coats ('Transactions of the Royal Society of Edinburgh'), was confirmed in none of the numerous Mediterranean representatives of that genus, who all carried the nerve-trunks outside the circular layer.

The *Cephalic Furrows,* so conspicuous in the larger Meckelian species, often less distinct in the enoplan forms, are universally in connection with the cephalic sacs, which latter seem to take a different position in the Enopla and in the Anopla. The shape of these organs in the armed Drepanophorus resembled that of the "side organs" in Keferstein's *Borlasia splendida,* though they were situated more behind the ganglia. They were connected with these by four commissures, which passed uninterruptedly from the ganglionic texture into that of the cephalic sac. Furthermore, they showed pigmented spots and a small knotty elevation on one side, which reached into the cephalic furrow. I could not make out distinctly whether an internal ciliated canal was present or not. In other enoplan species the position of the "side organs" is generally in front of the ganglia, with which they are connected by only one commissure.

The Borlasian subdvision shows a rather different distribution of the parts. The cephalic sacs lie behind the ganglia; they have a spherical or pyriform shape, and generally a distinctly visible internal ciliated canal, corresponding with the cephalic furrows and permitting the sea-water to enter freely. In their posterior portion they carry translucent globules figured successively by Van Beneden, MacIntosh, and myself.

The structure of the cephalic sacs in this subdivision was studied by me in several series of sections through them and through the ganglia, a reconstruction of the whole being in this way obtained. It then became evident that their constitution entirely corresponded with and immediately passed into that of the ganglionic lobes. Not only, as I remarked above, do the central bundles pass from the one into the other, but the enclosing layer of nerve-cells is quite as thick and conspicuous; the central ciliated canal can be traced in these transverse sections with perfect accuracy. It terminates in the central fibrous bundle, continues its way directly through the tissue of nerve-cells, passes upwards in the space left free between the superior and inferior lobes (Meckelia somatotomus), finally to find its way into the cephalic furrows. The same sections with identical results were made by me of *Borlasia olivacea* from the Dutch coast; nerve-cells and canal were quite as distinct.

The cephalic sacs in the Borlasians must on these grounds be regarded as belonging morphologically to the ganglionic texture with which they are in uninterrupted continuity.[1] Now, as it is chiefly in this group that the ganglionic tissue contains a considerable quantity of hæmoglobin, with its well-known property of binding free oxygen, and as the oxygenated sea-water has a free access to the hæmoglobinous nerve-cells by means of the cephalic furrows and ciliated canals, I do not hesitate to regard the cephalic sacs *as a special respiratory apparatus providing the cephalic hæmoglobin with fresh supplies of oxygen.*

How this respiratory process in the central nervous system may influence the organisation and the life of these animals remains for the present unexplained, as long as similar observations in other groups have not yet been made upon which comparative researches might be based.

Generative Organs and Development.

I have little to add to what is mentioned by Mr. MacIntosh under this head. The change which takes place in the intercœcal dissepiments when the generative products make their first appearance, and the space occupied by these between the constituent plates of these dissepiments has been already mentioned above (Plate XIII, fig. 8). Genital apertures giving access to these cavities were present on the dorsal side of the animal. Generally the emission of the eggs or the sperma took place by all the apertures simultaneously. My observations on the development of *Borlasia olivacea* agree, as far as they have been made, with those of Mr. MacIntosh. Circumstances have prevented me from carrying on continuous series of experiments on the development of other species where the more interesting Pilidium larva makes its appearance in the evolutional cycle.

March, 1875.

[1] The appearance sometimes presented in *Borlasia olivacea* as if they lay independently behind the ganglia, must probably be ascribed to an abnormal tension under compression, the elastic tissue so constantly distributed along with the nervous permitting of this separation for a short time; similar disjunction was never observed in the Mediterranean species.

On some NEW POINTS *in the* STRUCTURE *of* AMPHIOXUS, *and their* BEARING *on the* MORPHOLOGY *of* VERTEBRATA. By E. RAY LANKESTER, M.A., F.R.S., Fellow of Exeter College, Oxford, and Professor of Zoology and Comparative Anatomy in University College, London.

WITH the assistance of my pupil, Mr. Fanning, of Exeter College, I have recently (December to March) prepared a large number of specimens of *Amphioxus* by means of transverse, oblique, horizontal, and vertical sections. The specimens were collected by me at Naples in 1871 and some 1874, were preserved in absolute alcohol simply, others had been previously treated with dilute picric acid (according to Kleinenberg's plan), others had been first of all placed in H. Müller's fluid. The dissection and slicing of these specimens was carried on in the histological laboratory of Exeter College, but I had also made some examination and drawings of *Amphioxus* in the living state when at Naples.

Recently attention has been directed to certain points of structure in *Amphioxus* by Haeckel,[1] by Ludwig Stieda,[2] by Huxley,[3] and by Wilhelm Müller.[4] There is a remarkable divergence on many points in the statements of these and earlier writers, and whilst awaiting the completion of the drawings which Mr. Fanning intends to publish in illustration of the anatomy of the Lancelet, I may briefly set down some of our more important conclusions. I shall refer to the illustrations in the memoir of Stieda ('Mém. de l'Acad. St. Pétersbourg,' vii série, tome xix, No. 7. Plates I—IV), which, though inaccurate in some important respects and deficient in detail, will enable me to make clear my meaning in the absence of special illustration.

There are two causes which seem to have led to a diversity of opinions in connection with the anatomy of *Amphioxus*. Firstly, the action of the reagents which are used for preserving the specimens leads according to circumstances either to an excessive distension of cavities, accompanied by the separation of membranes which are in the living state adherent one to another, or on the other hand the reagent brings about an

[1] Ernst Haeckel, 'Anthropogenie,' p. 667. Leipzig, 1874.

[2] Stieda, "Studien ueber den Amphioxus lanceolatus," 'Mem. de l'Acad. de St. Petersbourg,' vii serie, tome xix, No. 7, 1873.

[3] Huxley, "The Classification of Animals," 'Quart. Journ. Micros. Science,' Jan., 1874.

[4] W. Müller, "Ueber das Urogenitalsystem des Amphioxus und der Cyclostomen," 'Jenaische Zeitschrift,' vol. ix, p. 94, 1875.

unnatural contraction and shrinking. Secondly, the season at which the specimens are taken may be either that in which the generative products are undeveloped or that in which they are in full maturity, and accordingly very considerable differences in the parts connected with the reproductive organs are to be observed. These causes will not, however, explain such a statement as that of Stieda, namely, that the pharynx is *not* perforated by slits leading to the atrial chamber. This is simply an error of observation.

1. *The Pharynx.*—It is not difficult to satisfy one's self, by the examination of sections and detached flakes from the pharynx, that it is really perforated by oblique-running clefts, and that these form a communication between it and the atrial chamber which opens to the exterior by means of the abdominal pore (atriopore). Stieda's statements on this point appear to me to be quite erroneous. The atrial chamber (postoral atrium or epicœl), like the mouth cavity (præoral atrium), is lined with a brown pigmented membrane which is continuous developmentally (in accordance with Kowalewsky's observations as to the mode of development of the atrial chamber) with the epiblast in each case. Now, this *brown pigmented membrane serves as a clear and simple line of demarcation* by which to trace out the limits of the atrial chamber. Stieda has not made use of this, and has not at all correctly represented the membranes which form the wall of the atrial and neighbouring chambers. The brown pigmented membrane can be traced in a vertical right and left section from the raphe in the middle line of the ventral wall (z of fig. 4, Plate I, Stieda) along the muscular floor, over the swelling generative sac, up to the muscular lateral wall (epipleur), whence it passes across to the suspended pharynx. Here it can be followed, *clothing each bar on the outer or atrial side,* and also continued across the short transverse bars, but plainly and certainly enough *absent* (as is all tissue or membrane) *from the space between successive bars.* It may be followed down to the lower border of the pharynx, and so traced over the structures of the right hand as of the left hand side of the section. The same membrane is reflected over the cœcum. Thus this brown pigmented membrane, which may be called the atrial tunic, gives a ready means of determining the boundaries and connections of the atrial chamber. It is to be observed that the atrial tunic is not equally pigmented throughout, being especially deficient in colouring matter at that part where it passes from the epipleural wall of the atrium to the pharynx. Of its continuity there is not, however, a shadow of a doubt. There are other points as to the

form of the pharynx, the structure of its walls, and median folds which I cannot enter into without figures.

2. *Boundaries of the atrial chamber.*—Anteriorly the atrial chamber commences with the pharynx; posteriorly it is continued *far beyond the atrial pore,* as far back as the anus. But it is to be noted that after the atrial pore is passed the atrial chamber (still lined by its pigmented atrial tunic) becomes very much diminished in size and pushed on one side (viz., the right) by the enlargement of the true perivisceral space or cœlom. In the region beyond the atrial pore the atrium, in transverse section, is reduced to a space one third the size (or less) of the cœlom in the same section.

3. *The true perivisceral space or cœlom.*—The space which thus enlarges posteriorly is represented throughout the course of the intestine, and has been correctly figured by Stieda as to general features in his Plate I, fig. 7 and Plate II, fig. 8. The space in question is perivisceral, extending round the intestine. It is traversed by certain blood-vessels and itself contains a coagulable fluid. It lies between two pairs of membranes which are readily distinguished. The outermost is formed by the visceral reflection of the pigmented epithelium of the atrial tunic and a fibrous supporting layer placed beneath. Then follows the space. Forming its intestinal boundary we find another fibrous layer, and internal to this we have the very thick intestinal epithelium.

This space is continuous with the uppermost of the series of chambers lying between membranous outgrowths of the pharyngeal bars, by means of which the upper part of the perforated pharynx is attached to the walls (epipleura) of the upper part of the atrial chamber. It is also continuous with the narrow space between any two folds attached to a single bar (see below). Stieda (*p* in figs. 3, 4, Plate I) correctly assigns the uppermost of these chambers to the pleuroperitoneal cavity (as distinct from the atrial chamber). The cœlom in the region of the pharynx becomes very much reduced, but it is obvious enough between the cœcum and pharynx in a transverse section. It can be traced as a very much reduced lymph-space in mid-line both above and below the pharynx in transverse sections. Figures are necessary to render its exact position in each region intelligible. It is further traceable beneath the parietal (epipleural) layer of the atrial tunic, being dilated in this position at certain points, especially in the region of the body posterior to the atrial pore. The genitalia are developed in epipleural dilatations of the cœlom.

Pharyngo-pleural septa, lateral attachments, or suspensory *folds of the pharynx.*—Stieda has figured these, but not quite correctly (figs. 3 and 4, Plate I). They consist of what appear in transverse section as fibres passing horizontally from the uppermost bars of the pharynx to the wall of the atrial chamber. In reality they are membranous folds, extending for some length along the bars to which they are attached. They become more numerous as one advances from the posterior to the anterior region of the pharynx, and in conformity with a change in the shape of the cross-section of that organ and the disappearance of the testicular and ovarian pouches in the anterior region of the body, they become developed from all the bars of the lateral region of the pharynx. These folds may be in parts adherent to the lateral wall of the atrial chamber on each side, and are very possibly *muscular*. The folds are double, being in fact but flat sacs formed by the outgrowth of the atrial tunic and its subjacent fibrous layer on *alternate* chitinous bars. The bars which do not give rise to a fold are *tubular;* those which do are solid. Each fold contains between its lamellæ a lymph-space (part of the cœlom). The spaces between the double folds are open posteriorly to the atrial chamber, but the pigment of the atrial tunic does not completely line them, and on the median side they are, of course, widely open to the pharynx by the two long slits, one on each side, of a tubular pharyngeal bar which is devoid of a fold. I propose to call these structures respectively pharyngo-pleural septa or lymph-sacs, and pharyngo-pleural inter-spaces.

Pigmented canals (*vertebrate renal organs*).—In examining transverse sections of *Amphioxus*, as we advance from behind forwards, we come to a part where the atrial chamber is occupied by the lateral generative pouches, by the cœcum but just given off, and by the so-called œsophagus. A few slices in front of this we get the first bars of the pharynx appearing, and then what might be mistaken for the first pharyngo-pleural septum is detected on each side, viz. a band running across from the dorsal region of the pharynx to join the body wall, and leaving a considerable space on each side of the sub-chordal attachment of the pharynx. A pair of vascular trunks lie in each of these spaces near the summit of the pharynx. The space on each side runs throughout the length of the pharynx. It is correctly marked as pleuro-peritoneal cavity in Stieda's Pl. I, figs 3 and 4. *Posteriorly* this space, which may be called the pharyngo-dorsal cœlom can be traced to complete separation from the alimentary canal existing only as a split in the double membrane which lines the epipleur, exactly like the neighbouring split in which the genital glands are placed. In each pharyngo-dorsal cœlom at its commencement a deeply pigmented canal is seen in section appearing as a thick irregular ring, lined within by a dark brown membrane, the pigment granules of which are disposed precisely as in the atrial tunic. The ring thus seen in the section is attached to the body wall (epipleur) by one side, the rest of the ring projecting freely into the pharyngo-dorsal cœlom. As far as I have yet been able to ascertain, this canal is open at each end, posteriorly communicating with the atrial chamber, anteriorly considerably contracted and possibly closed.

The pigmented canals are constant in position and form. I have found them in several specimens always in the same place and equally developed both in males and females. There is not much difficulty in tracing a similarity of relations between the pigmented canals of *Amphioxus* and a single pair of the funnel-like canals which build up the renal organ of higher Vertebrata. On this subject I shall add some reflections below.

Lateral folds (metapleura), lateral canals, ventral canals, and plaited epithelium.—The lateral canals have acquired special interest and importance from the suggestion by Professor Haeckel that they represent the primitive renal ducts of higher vertebrates.

Stieda figures these canals—the space in the lateral or marginal fold (metapleur) which stands up as a ridge on each side of the ventral area of Amphioxus—as seen in transverse sections; but they are somewhat over-distended in his specimens by *end*-osmotic action. Professor Huxley is inclined to deny their existence, and it certainly is the fact that in specimens preserved in absolute alcohol they are shrunk by *ex*-osmotic action to a very small size. Professor Wilhelm Müller, of Jena, asserts their existence and speaks of them as lymph spaces. This appears to me to be the correct view of their nature, and it would be better to cease speaking of them as 'canals,' since they have no openings either before or behind, but are simply loose spaces in the subcutaneous connective tissue. That they have a real existence is proved by the presence in them of coagulated serous fluid, and by other facts to be detailed below.

The *ventral canals* of Stieda's memoir (r' r') have a different nature. They are undoubtedly artifact. They lie between the epidermis and the subepidermic connective tissue, whereas the lymph space of the metapleura or latero-ventral folds lies between two layers of connective tissue. The ventral canals must be given up as illusions. Professor

Huxley has drawn attention to the very strongly marked plaiting or longitudinal grooving of the ventral integument. This is imperfectly figured by Stieda, but in specimens preserved in absolute alcohol it is very strongly marked. In cross-section of specimens preserved in picric acid (afterwards in alcohol) the longitudinal grooving is seen as a series of closely adpressed papillæ (the cross-sections of longitudinal folds). They vary in number from six to eight on each side of the median raphe, and are not always the same in number on the two sides. The epithelium which covers them does not differ from that of the rest of the surface of the body. Professor Huxley has observed these plaits in the living animal, and my friend Mr. Balfour, who has recently (at my request) been so obliging as to examine living specimens of Amphioxus at Naples as to their occurrence, reports that in the winter and spring (when, it must be remembered, the genital products are not *fully* developed) these 'rugæ' are always present, and can be seen without subjecting the animal to any restraint. Mr. Balfour further states that the plaits differ sometimes in number on the two sides of the middle line, and also become more or less distinct according to the distension of the atrial cavity.

I was led to ask for this information concerning the living Amphioxus since I have some specimens of the animal taken in May, when fully distended with ova (preserved first for a week in Müller's fluid, then in weak and subsequently in absolute alcohol), which specimens show in transverse sections no trace of the plaited epithelium of the ventral surface. The atrial chamber is largely distended by the massive generative products and the ventral musculature and integument is stretched out tight and smooth. What is still more remarkable in these specimens is the absence of the metapleura which were figured by Johannes Muller in 1842, and which in specimens preserved in absolute alcohol present the curious inflection towards the middle line, so as to form an incomplete subventral canal, as described by Professor Huxley and subsequently by Professor Wilhelm Müller in almost the same words, and as shown by many sections cut by Mr. Fanning and myself. It appears that in consequence of the distension of the atrial chamber by the swelling genitalia, not only are the plaits of the ventral integument smoothed away, but that the base of the triangle which the latero-ventral (metapleural) lymph space presents in transverse section, is so much stretched and increased in length that the angle opposite to the base becomes more and more obtuse and finally disappears, the two sides lying now in close apposition and parallel to the base. This is explained by the diagram (fig. 1). The remarkable

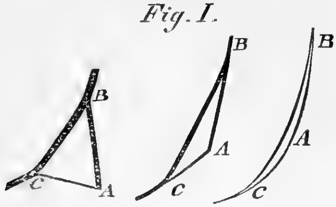


Fig. 1.—Diagram to illustrate the change in the lumen of the metapleur of Amphioxus, consequent upon distension of the atrial chamber.

variety of connective tissue by which the outer (dorsal) wall of the latero-ventral lymph space is formed, which Wilhelm Müller compares to erectile tissue (see Stieda, fig. 4, *g*), is possibly connected with this periodical distension which must recur at every breeding season. In the living specimens which I examined last year the latero-ventral folds or metapleura (which are obvious enough when the sexual products are of half size) did not cover in the ventral integuments, but stood up on each side of it, leaving a broad area absolutely exposed between them. On placing such specimens in alcohol the water in the atrial and other cavities is removed and the whole organism shrunk, and then it is that the metapleura (latero-ventral, lateral or marginal folds) project inwards to form an incomplete subventral canal.

By the side of Kowalewsky's statements as to the ejection of the eggs ('ausgeworfen') is the word he uses) from the mouth of Amphioxus, I cannot admit Prof. Wilhelm Müller's conclusion, who says that the eggs *must* pass out by the atrial pore, together with the water from the branchial sac. He adduces as a reason that the branchial slits are too fine for the eggs to pass in between them. It appears to me that they are *not* too fine, especially in the anterior region, and that the eggs probably *do* escape by the mouth or else (and more probably) by the two apertures placed one on each side of the mouth, which Johannes Müller first described (Pl. III, fig. 4, *d*, Berlin Akad., 1842) and which no one appears to have seen since. I have recently found these apertures, as to the existence of which there could scarcely be a doubt in the face of the positive statement and drawing of Johannes Müller; and I will now direct attention to them.

Hyoidean apertures (*J. Müller's pores of the lateral canal*).—The apertures in question are placed one on either side of the true mouth within the præoral atrium or open continuation of the epipleura, which forms the oral hood or upper lip of Amphioxus. They do not communicate with the lymph-spaces in the two latero-ventral folds as J. Müller supposed, but they lead into the anterior angles of the pharynx, perforating the septum which divides præoral from postoral atrium. They thus correspond exactly in their relations to other parts with the hyoidean slit of the young Petromyzon Planeri, to which Prof. Huxley has drawn attention in the comparison of the heads of Petromyzon and Amphioxus ('Proc. Roy. Soc.,' Jan., 1875). The existence of these hyoidean apertures in Amphioxus tends to confirm the truth of the views which he has expressed as to the agreement of various parts in the two animals.

Præoral atrium and true mouth, or pharyngeal orifice.—At present, in the absence of drawings, I will merely point out that the so-called buccal cavity is formed by the forward continuation of the two lateral growths (epipleura) which form the side-walls of the atrial chamber. These atrial parietes or epipleura at their anterior termination remain disunited in the middle line; but, nevertheless, on account of its homology, we may speak of the unclosed space as well as of the closed one by the common name 'atrium.' The præoral atrium is lined by a membrane dotted with brown pigment, exactly as is the postoral atrium and the two pigmented epithelia are (according to Kowalewsky) developmentally continuous. Posteriorly, this oral cavity is closed by an obliquely-placed inflection of its walls. In the lower part of this obliquely-directed wall is a small orifice facing downwards and forwards, and surrounded by a very thick and powerful sphincter muscle. This orifice (which appears to be the *original* mouth) leads by a short passage upwards and backwards through the thickness of the sphincter muscle into the capacious pharynx, which above extends forward beyond the vertical plane of the pharyngeal orifice. The pharyngeal orifice and sphincter, when that portion of the pharynx is removed and looked at in the horizontal position from the oral side, has the appearance of a solid circular mass with a conical central depression narrowing to a fine passage. On each side, forming the angles of the pharynx, are seen the duct-like connections of that organ with the hyoidean slits or pores.

Structure of the Notochord.—I am able to confirm Dr. R. Kossmann ('Verhandl. der Würzburger Phys. Med. Gesellschaft,' Neue Folge, vol. vi) as to the existence of a series of stellate cells in the upper median line of the notochord. Dr. Kossmann (for the knowledge of whose paper I have to thank Mr. F. M. Balfour) was unable to find similar cells in the corresponding opposite or ventral region of that organ, though there too a cavity is observed in transverse sections. I have found such cells in this part of the notochord also.

Muscles of the median portion of the conjoined epipleura (ventral wall of the atrial chamber).—Stieda's figure 8, Plate II, is incomplete, in that amongst other things he omits the longitudinal muscular bands (related functionally to the distension of the atrial chamber and the opening of the atrial pore). These narrow longitudinal bands appear in such a section as detached processes on the inner face of the transverse muscular mass.

Relationship of the epipleur, atrium, cœlom and pigmented canals of Amphioxus to the cavities and canals of higher Vertebrata. The remarkable suggestion of Professor Huxley to the effect that the peritoneal cavity of the higher Vertebrata might correspond genetically to the atrial chamber of Amphioxus, and might then be distinguished as an epicœl (formed ancestrally by the coalescence in mid-line of two lateral folds) in contradistinction to the 'schizocœl' and the 'enterocœl' of various Invertebrata, led me to frame, by way of deduction from what seems to me a most fascinating and pregnant generalisation, certain questions which have stimulated the observations recorded in outline above. The case appeared to me thus: if the Vertebrata are descended from Invertebrate ancestors which were provided with a cœlom or space in the mesoblast (either enterocœl or schizocœl); and if the Vertebrate's peritoneum (in spite of its schizocœlous ontogeny) does *not* correspond to that ancestral cœlom, but is a new thing, an epicœl, one should be able to show what has become of that ancestral cœlom. Has Amphioxus any trace of it? The answer to that question appears to me to be, that Amphioxus has a very extensive space corresponding to the Vermian cœlom, especially developed in the post-atrioporal portion of the body. In tracing the cœlom I came upon the pigmented canals, which suggested a comparison with the simplest condition of excretory canal seen in higher Vertebrates.

In this connection I at once referred to Mr. Balfour's researches on the development of Elasmobranchs, remembering the remarkable position in which, according to his observations, the oviduct makes its first appearance in those Vertebrata, namely, *externally* to the somatopleur (parietal lamina of the splitting mesoblast). In consequence I submit the subjoined diagrams.

The conclusions to which they point are, first, that the peritoneal cavity of the Vertebrate *is* the same thing as the

Fig. 2.

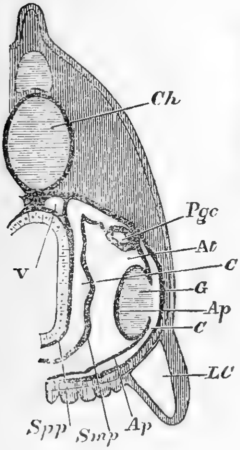


Fig. 3.

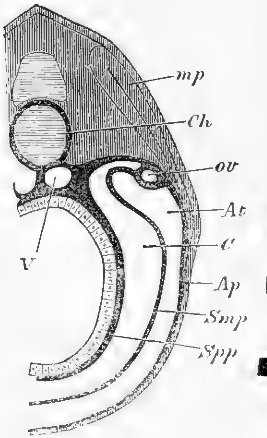


Fig. 4.

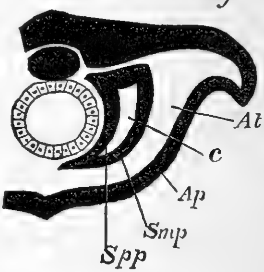


FIG. 2.—Schematic transverse section of Amphioxus, to illustrate the relations of the cœlom and atrium. N.B. The cœlom is purposely exaggerated in dimension. *V.* Blood-vessel. *Ch.* Chorda dorsalis. *Pgc.* Pigmented canal. *G.* Ovarium. *L C.* Lymphatic space of the metapleur. *C.* Cœlom. *Spp.* Splanchnopleur. *Smp.* Somatopleur. *At.* Atrium. *Ap.* Epipleur.

FIG. 3.—Schematic transverse section of embryo Elasmobranch (modified after Balfour). *ov,* oviduct; *mp,* muscle-plate. Other letters as in fig. 2.

FIG. 4.—Schematic transverse section through the cephalic region of a younger embryo of an Elasmobranch (after Balfour). Letters as in Fig. 2.

cœlom of the Worm and of Amphioxus; second, that the earlier vertebrate ancestors (represented in a degenerate form by Amphioxus) developed epipleura, which coalesced in the median line postorally to form an atrium; third, that whilst Amphioxus retains this atrium in functional activity, the other Vertebrata have lost it by *the coalescence* of its outer and inner bounding-walls, respectively epipleur and somatopleur. Fourth, that whilst the indications of the earlier historical steps of this process are suppressed in all Craniate Vertebrata at present investigated, yet the Elasmobranchs do continue to present to us an ontogenetic phase in which the somatopleur and the epipleur are widely separate; thus enclosing between them an epicœl (the atrium in Amphioxus).

Moreover, in the young Elasmobranch, as in the adult Amphioxus, the excretory canals placing the cœlom (pharyngodorsal cœlom of Amphioxus, pleuro-peritoneal cavity of shark) in communication with the exterior, are open involutions of the wall of the atrial chamber or epicœl, and therefore aboriginally of the ectoderm.

Before discussing further the homologies which are thus suggested (I say advisedly 'suggested' as appropriate to such speculation), it seems most desirable that possible sources of direct confirmation or destruction should be thoroughly interrogated; above all, the ontogenetic forms of the Lamprey.

I subjoin a list of the new (and of some of the old) terms which have been used in this paper.

1. *Atrium:* the space enclosed by the downward growth of two folds, one running along the greater part of each side of the embryo. The præoral portions of the two folds do not meet below; they partially enclose an open space, the buccal cavity or prœoral atrium. The post-oral portions of the folds, which are called '*epipleura*,' coalesce in the middle line, and form the post-oral atrium or *epicœl*—the chamber into which the pharyngeal slits open.
2. *Atriopore:* the posteriorly placed ventral aperture, by means of which the post-oral atrium communicates with the exterior.
3. *Atrial tunic:* a brown pigmented membrane, which lines the sides of the atrium and of the organs suspended in it.
4. *Cœlom:* the primitive body-cavity found in the Worms.
5. *Entero-cœl:* a body cavity, formed by a pinching off of the primitive *enteron*, or alimentary canal.
6. *Epicœl:* a body-cavity, formed by the outgrowth and coalescence of folds of the primitive body-wall.
7. *Epipleura:* the lateral down-growing folds which, by their coalescence in the middle line below, form the atrium or epicœl.
8. *Metapleura:* the upstanding hollow ridges or latero-ventral folds which, in Amphioxus, form the lateral margins of the ventral surface.
9. *Pharyngo-dorsal cœlom:* that portion of the cœlom which exists on the dorsal surface of the pharynx on either side of its attachment to the notochordal sheath.
10. *Pharyngo-pleural septa:* the double folds by means of which the upper part of alternate pharyngeal bars are attached to the epipleura.
11. *Pharyngo-pleural interspaces:* the open spaces between the septa, communicating with the pharyngeal cavity and with the atrial chamber.
12. *Postatrioporal:* that which is posterior to the atrial pore.
13. *Schizocœl:* a body-cavity formed by the splitting or separation of the primitive muscular body-wall (*somatopleur*), and primitive muscular gut-wall (*splanchnopleur*).

On NEMATODE HÆMATOZOA *in the* DOG. By T. R. LEWIS, M.B., Staff Surgeon, H.M. British Forces, attached to the Sanitary Commissioner with the Government of India. (With Plate XIII, figs. 1 to 5.)[1]

WHEN making a microscopical examination of some gland-tissue from the mesentery of a pariah dog, I observed that the sanguineous fluid squeezed out of the preparation on the slide contained numerous minute nematode worms in a state of great activity, and presenting at first sight a marked resemblance, both as to the character of their movements and their size, to the hæmatozoa formerly described as existing in human blood. I had long been desirous of obtaining living specimens of a canine hæmatozoon for comparison with those found in man, though not with any very sanguine hope of thus pronouncing as to their identity, since it is well known that the embryos of many *Filariæ* of widely differing size and habitat present no appreciable difference either of size or form.

With respect, however, to the particular hæmatozoa under consideration, I have no hesitation in pronouncing them to be totally distinct parasites. No indication whatever can be detected of this canine hæmatozoon being enclosed in any enveloping tube, such as the structureless hyaline tubular sac enclosing the human parasite.

The internal structure of both is, however, pretty much alike; in neither is there any visible differentiation of the reproductive organs, and only in a very minor degree of the alimentary tract; if anything, the canine parasite is perhaps the more advanced.

Before attempting to arrive at any conclusion as to the probable or possible source of these embryos, it will be advisable to describe briefly the pathological conditions which usually accompany their presence. These, as far as may be inferred from very careful dissections of the twenty-seven dogs above referred to, may be described as follows:

1. The most striking feature is the existence of fibrous-looking tumours, varying from the size of a pea to that of a filbert or walnut, along the walls of the thoracic aorta and œsophagus, both tubes being affected, or only one.

[1] "Abstract of a Report on the Pathological Significance of Nematode Hæmatozoa," forming an appendix to the 'Tenth Annual Report of the Sanitary Commissioner with the Government of India.' Calcutta, 1874.

2. Minute nodules in the substance of the walls of the thoracic aorta, from the size of duck shot to that of split peas. They can be felt as tubercles, and usually project somewhat on the outer surface of the vessel; a depression or slight extravasation of blood, corresponding to the nodule, being visible on the inner surface of the aorta, and frequently a slight abrasion of the lining membrane.
3. A pitted or sacculated appearance of various portions of the interior of the thoracic aorta with thinning of its walls at some parts; the lining membrane roughened at the spots affected; the roughening, however, is not of an atheromatous character, but due to the membrane being thrown into delicate rugæ, as if from contraction of the middle and outer coat.
4. Enlargement and softening of some glandular body adjoining the vessels at the base of the heart.

Within the above four headings is comprehended everything abnormal that I have been able to detect, which seemed to imply any connection with the state of the blood under consideration.

(1) As regards the first point referred to, the tumours manifest a somewhat firm, fibrous texture, and when cut into are found to contain one to six or more mature nematode worms of a pinkish, sanguinolent tint, and varying in size from one inch to three and a half inches in length. These on closer examination prove to be the male and female of the same parasite: the male worm being from one to two inches long, and $\frac{1}{50}$th to $\frac{1}{40}$th of an inch in diameter at the widest part; and the female from two to three and a half inches long with a transverse measurement of from $\frac{1}{30}$th to $\frac{1}{25}$th of an inch. (Plate XIII, figs. 4, 5.)

These parasites correspond more closely to the *Filaria sanguinolenta* (Rudolphi), especially to the description of this species given by Schneider, than to any other nematode with which I am acquainted, although in some respects they differ from the descriptions given of any.

It is, however, with regard to the parts of the body in which these parasites are found that the most marked discrepancy exists, for all writers, as far as I am aware, with the exception of Czernay,[1] appear to speak of them as confined to the walls of the stomach of the dog or wolf. This writer, however, has drawn attention to the fact that they may also be found in the walls of the œsophagus. Notwithstanding the somewhat extended reference to the works of systematic

[1] 'Bulletin de la Soc. Imp. des Naturalistes de Moscow,' tome xxxviii.

writers on these and allied subjects, which, through the courtesy of Mr. Wood-Mason, Curator of the Indian Museum, I have been able to make, I can find no mention of their lodging themselves in the walls of the blood-vessels.

(2) As far as the aorta is concerned, the condition referred to under the second heading is the one of most frequent occurrence; and as in this conditon the parasite may be obtained in various stages of advancement, it will be better to describe the smaller tumours and their contents before referring more minutely to the mature *Filaria,* especially as this will give an opportunity of studying the growth of the parasite from a very early period till it reaches maturity. Specimens in almost every stage of development may sometimes be found lodged in the walls of a single aorta.

Although the tumours enveloping the young are much smaller than those in which the mature worms are usually lodged, the lesions, as far as the tissues of the walls of the artery are concerned, appear to be of a more serious nature, for frequently the walls of the vessel are very fragile at various places, and there is a considerable roughening of its inner wall.

Towards the earlier stages of the attack of this parasite a cursory examination of either the inner or the outer surface of the aorta may not convey to the observer the impression that there is anything unusual present, but on closer inspection slight indications of roughening or of dryness of the inner surface will be evident, as if indicative of commencing atheromatous changes. There may be either a small depression at the part or a slight elevation, and when the artery is drawn between the finger and thumb, a little tubercle, varying in size from that of a millet-seed to that of a pea, may be more or less clearly evident. Frequently also, on careful examination, a thin serpentine line may be detected lying immediately beneath the inner coat of the artery.

When one of the smaller tubercles is cut into and the tissues carefully dissected under a low magnifying power, a curled, hair-like object will generally be observed; this, when examined under a higher power, will be found to be an immature worm, but manifesting considerable evidence of organization and in a state of great activity. They may be so small as not to exceed $\frac{1}{10}$ of an inch in length or more than $\frac{1}{150}$th transversely at the widest part. Some yield even smaller measurements than this.

At this stage of development no reproductive organs can be discerned. The oral end terminates in two pointed papillæ, dorsal and ventral, which can be brought closely together, so as to form a sort of 'borer,' by which means, possibly, the parasites bore their way through the tissues. The alimentary canal is well differentiated, the œsophagus occupying above $\frac{1}{3}$rd of the entire length of the worm: a well-marked sphincter-like constriction exists a short distance below the mouth, probably indicating the junction of the pharynx with the œsophagus. The intestinal canal terminates on the convex surface, a short distance from the end of the tail; the latter is somewhat blunt, and is tipped with a trefoil-like object (glandular?), communicating with a tube and apparently containing a transparent fluid.

During this period of its growth the worm undergoes a moulting process—casting off its skin entirely. When the cuticle has become somewhat separated from the body of the worm shortly before the 'moulting' actually occurs, the continuation of the old cuticle with the lining of the oral and anal orifices is very evident, as also the fact that it forms a coating to the tri-lobed gland-like object at the caudal extremity.

This process of moulting appears to be repeated several times, and each time some slight modification occurs in the appearance of the worm, especially at both ends; it also increases in size. The prominent papillæ with which the mouth is furnished gradually disappear, and, by the time that the worm has acquired a length of about $\frac{3}{4}$ths of an inch, reproductive organs can be distinctly made out and the sex identified. No ova, however, can be detected in the genital tube of the female at this stage, and the spicula in the male are not developed until after the spermatic tube and the sheath of the retractor muscles of the larger spicule. The œsophagus is proportionally much shorter, and the tri-lobed object at the caudal extremity almost completely disappears.

The worm gradually acquires a more decidedly pinkish hue, and instead of occupying a little tumour alone, as it did when very small, it appears to make its way into some adjoining tumour. Other worms also migrate to this, so that one tumour may be common to several parasites. It should, however, be noted that they do not occupy a single cavity, but each tumour is tunnelled in various directions, so there is frequently some difficulty in pulling out the parasites without tearing or otherwise injuring them.

Sometimes they may be seen to have crept outside the tumour, lying between it and a serous covering investing the artery, or a parasite may be seen emerging through a minute orifice communicating between the tumour and the interior of the aorta and swinging itself across the lumen of the artery. I have observed the channel of the aorta almost entirely blocked up after death by a clot which had formed around a worm in this position.

When the parasites have acquired a length of about $\frac{3}{4}$ths of an inch to an inch, and a transverse diameter of about $\frac{1}{40}$th, they will be found to have acquired nearly all, if not all, the microscopical characters distinctive of the *Filaria sanguinolenta;* and, as already mentioned, every stage in the development may be represented by examples of the parasite in the tissues of a single aorta—in the thoracic portion of it: I have never observed the abdominal aorta to be affected in this manner, nor have I observed the parasite in this condition in any tissue beyond the limit of the thoracic cavity.

(3.) With regard to the third heading into which the pathological features of this phase of parasitism have been divided, namely, the sacculated external and scarred internal appearance of the aorta, it may be observed that these changes appear to have been produced by the development of the filaria as above described, by their subsequent migration to adjoining tumours and various tissues; and probably, also, by the death and subsequent softening and absorption of some of the parasites—an assumption supported by the fact that, frequently, on pricking an affected spot of this kind, on the walls of the aorta nothing is found except an accumulation of soft pultaceous substance filled with fatty molecules and plates of cholesterin.

(4.) Sometimes the three foregoing classes of morbid appearances may be found to occur in a single animal; indeed, the only occasion on which I observed the condition described under the fourth heading, now to be referred to, was also associated to some extent with the other three. The blood of a dog was found to be affected to a slight degree with hæmatozoa, and the aorta was scarred and nodulated; but no mature parasites could be detected anywhere, except in a tumour in the walls of the œsophagus. On careful examination of the thoracic viscera, however, a gland, or what seemed to be one, was observed to have become enlarged and softened near the origin of the left carotid artery. This tissue, on being cut into, was found to have degenerated into a pultaceous mass composed of oil molecules and plates of cholesterin; but coiled in the midst of this softened material were five mature specimens of the *Filaria sanguinolenta* —male and female.

This observation shows that the mature parasites, at all events, may be found in other tissues than those of the thoracic aorta and œsophagus.

It is not deemed necessary to enter into any very minute description of the anatomical characters of the matured *Filaria sanguinolenta* as found in dogs in India, as these do not differ very materially from those of any other filariæ which have been described by various writers from time to time.

The figures in Plate XIII will, I trust, be sufficient to give a tolerably clear idea of the general appearance and internal anatomy of the mature entozoon when examined under the microscope; but it should be remarked that, in some instances, a higher power has been used to make out the structures than the extent of amplification stated opposite each figure would imply. To have drawn the figures to scale, as observed under higher powers, would have added greatly to the difficulties of reproducing them without adding materially to their value. Fig. 3 represents the mouth with its six, indistinctly marked, "lips," and entrance to the pharynx as seen from the front. Fig. 2 represents the ventral aspect of the tail of the male with its two dissimilar spicules and four pre-anal papillæ—characters which, when taken in conjunction with the arrangement of the muscular tissues of the body, form the distinctive features of the genus *Filaria* (Schneider). There are also two post-anal papillæ, placed transversely to the body of the worm; so that in all there are twelve papillæ, terminating on the inner surface of the alæ which form the boat-shaped cavity on the ventral aspect of the coiled tail of the male.

The well-marked curvature of the tail of the male, so common among the *Filaridæ*, is, in this case certainly, due in a great measure to the strength and elasticity of the larger spiculum; when this is extracted the curvature loses its firmness. The alimentary tube runs parallel with the spermatic tube, a sphincter-like constriction occurring on the course of the latter, separating the "*vas deferens*" from the "testis." The "testis" consists of a tube extending upwards in a serpentine manner until the junction of the upper with the middle third of the body and terminating cæcally.

The head of the female worm (fig. 1 *a*) does not differ from the head of the male, except that it is somewhat larger. The specimen delineated had been immersed in spirit, which had separated the chitinous cuticle from the other tissues; so that the continuation of the former with the pharynx has been made very evident, the pharyngeal membrane being merely a reflection inwards of the skin; a similar reflection takes place at the other end of the alimentary canal. The course and texture of the œsophagus and intestinal canal are the same as in the male, and do not differ from such structures in the *Filaridæ* generally.

The vagina (fig. 1 *b*) terminates about $\frac{1}{6}$th of an inch below the oral extremity, generally a little above the junction of the œsophagus with the intestine, as represented in the plate. It is a well-developed muscular tube, composed of longitudinal and transverse fibres, and the channel is occupied by a row of ova lying two or three abreast. It is about $\frac{1}{4}$th of an inch in length, is curved upon itself about the middle, and divides into the two uterine tubes delineated in the figure (1 *b*). These tubes are also filled with ova, each ovum containing a more or less clearly differentiated embryo, especially towards the vaginal end; but in no part of the genital tract are free embryos to be found. On tracing the course of the uterine tubes by means of a low power until within about a quarter or half an inch of the caudal extremity (fig. 1 *c*), they are found to terminate in still smaller tubules (the ovarian); and these, after forming numerous coils around and alongside the intestinal tube, terminate abruptly in a cæcal manner, retaining pretty much the same diameter throughout their entire course.

The caudal extremity (fig. 1 *c*) of the female is not so complicated as that of the male; it is very slightly pointed, and at its extremity something suggestive of the remnant of a gland, or of the site of *exit* of the water-vascular system, may frequently be discerned: in the male also a similar appearance may often be detected.

The ova in the earlier stages are oval, but as the development of the contained embryo advances, the firm though thin "shell" becomes more elongated and the ends of the ovum more blunt. The ova are about $\frac{1}{750}$th of an inch in length and about $\frac{1}{1000}$th in width. When a ripe ovum is crushed beneath the covering glass a well-developed embryo escapes, which, however, does not manifest any activity.

The embryos when thus deprived of their covering vary somewhat in size, the average dimensions, of the particular specimens measured, were found to be about $\frac{1}{200}$th of an inch from end to end and about $\frac{1}{6000}$th at the widest part—just $\frac{1}{30}$th as broad as long. With reference to these embryos it may be further remarked that the thickish, yellowish fluid in which the mature worms are imbedded may be squeezed through the orifice in the tumour (usually found without difficulty) communicating either with the aorta or the œsophagus, according to its anatomical relations. In this way innumerable ova may be made to pass into either channel, as the fluid is well charged with eggs in all stages of development.

I have not, however, observed any free embryos in this fluid, nor could I find any along the whole course of the intestinal canal in the dogs examined, where the parasites were lodged in tumours in the œsophageal walls, although plenty of ova, apparently unaltered, could be detected throughout the entire gut.[1] On one occasion only have I observed ova on a slide of blood containing hæmatozoa: this preparation was obtained by scraping the inner surface of the aorta with the edge of a covering glass.

It would, therefore, appear that the ova require some considerable time before the escape of the embryo takes place, certainly a longer period than is sufficient for them to be conveyed the entire length of the intestinal canal.

I have made numerous attempts at bringing the embryos to maturity: by means of moist earth; by feeding cockroaches with bread soaked in fluid containg ova; by introducing ova into the stomach and peritoneal cavity of frogs, &c., but have not yet succeeded—the ova and their contained embryos being, from a week to a fortnight afterwards, detected in the bodies of the animals without having undergone any apparent change.

Where the true habitat of these embryos may be is as yet unknown. Whether, after a lengthened sojourn in moist earth, or in water, or in the intestinal canal of some creature other than the dog, the embryo escapes and undergoes developmental changes, must be left for future inquiry, as must also the direct proof that the microscopic worms in the blood of the pariah dog are the brood of the *Filariæ sanguinolentæ* which may be lodged in the walls of the aorta or œsophagus, or in some other tissue, glandular or connective, about the base of the heart or elsewhere. All that I can say is that all my attempts at finding any other mature nematode in the vascular system of dogs affected with hæmatozoa have proved fruitless, and I have made careful examinations—macroscopic and microscopic—of every tissue and organ of the bodies of several animals, and followed the ramifications of the various arteries and veins in the trunk and in the extremities. On one occasion, no trace of any mature parasite in a hæmatozoa-affected dog could be found, but it is quite possible that the parent may have escaped detection by being lodged in some out-of-the-way tissue in the body, and one

[1] *Dochmius trichono cephalus* is the ordinary nematode entozoon found in e intestines of dogs in India.

worm might contribute many thousands of ova; or the worm, after depositing its ova, may have taken its departure, or have died and become disintegrated. The scarred and sacculated condition of the aorta, already described, which is sometimes observed unassociated with any parasite at the time of the examination, shows that the worm that produced the lesion may altogether disappear.

Moreover, we require to know far more than is at present known concerning the development and parentage of these canine microscopic blood-worms, before anything definite can be stated with reference to their relationship to similar organisms found in the blood of dogs in France, China, Japan, and America.

So far as I am aware, Dr. Spencer Cobbold is the only author who has suggested that the young of the *Filariæ sanguinolentæ* may possibly find their way into the blood[1]—a suggestion which is the more noteworthy, seeing that, to the best of my knowledge, no observations had been recorded showing that this nematode ever penetrated the arteries.

Although I have not been able to keep individual dogs affected with this hæmatozoon during any lengthened period, still there can hardly be any doubt but that, as has already been shown with reference to the human hæmatozoon and been previously remarked concerning hæmatozoa in animals generally,[2] these microscopic worms may exist for a considerable time in the blood (unaltered after having attained a certain, very imperfect stage of development), showing that they were not in the place or fluid fitted for their growth. Their presence in the blood, it may therefore be presumed, is accidental, or if not exactly accidental, the young brood requires at least to be transferred to some other habitat before undergoing even the most elementary morphological changes.

When, however, the ova or liberated embryos of the *Filaria sanguinolenta* find their way into a 'host' or other medium suitable for their development they enter the larval stage—a stage in their development carried on, possibly, to the extent of providing the embryo with some kind of oral armature and a differentiated intestinal tube. Having acquired this stage of growth, the further progress of the parasite is probably dependent on its being swallowed by some such animal as the dog, to the mucous lining of whose œsophagus it attaches itself, then penetrating the muscular

[1] 'Entozoa: an introduction to the study of Helminthology,' London, 1864, p. 95. Supplement to ditto, p. 63.

[2] In dogs in France and China; in the frog, and in the crow.—Leuckart.

tissue of this tube and remaining there or working its way still further till it reaches the tissues of the thoracic aorta, or some other place suitable to its growth and development; the various stages of which, when the aorta has been selected, have been described on a previous page.

With reference to the morbid phenomena indicating the presence of these parasites in the vascular system of dogs during life, I have no definite knowledge. Some of the affected animals have been of the most miserable kind, others have appeared to be in the enjoyment of perfect health—facts which appear to me to favour the inference that when actual mischief does take place, the cause may be due to the lesions induced by the migrations of the growing and more or less mature parasite, rather than by the microscopic brood in the blood. It would not surprise me, should it eventually be demonstrated, that the haggard, loathsome appearance presented by a great number of the pariah dogs of every Indian town is, in many instances, primarily due to the injuries inflicted on the vascular and other tissues of the animals by these parasites.

On Amphiporus spectabilis, *De Quatrefages, and other* Nemerteans. By W. C. M'Intosh, M.D., F.R.S.E., F.L.S. With Plates XIV and XV.

The description of *Amphiporus spectabilis* (*Drepanophorus*, Hubrecht) in the 'British Annelids,' Part I, published by the Ray Society, was drawn up from a single fine example procured off Guernsey, but, as formerly stated,[1] its rapid dissolution after spawning prevented so minute an examination of the proboscis and other parts as might have been wished. It then appeared clear that the animal was a true representative of the *Amphiporidæ,* and further opportunity of examination does not alter its relationship to any degree. I have, however, to acknowledge that the doubts expressed as to the accuracy of the description given by the distinguished M. de Quatrefages, of the structure of the central stylet of the proboscis of this species were without foundation, for though I have not yet had an opportunity of seeing the peculiar curved central stylet or its surroundings, the

[1] Op. cit., Part I, Nemerteans, p. 162.

representations of Dr. Hubrecht,[1] the able Conservator of the Museum at Leyden, and the remarks by M. Marion,[2] show that M. de Quatrefages was quite right when he doubtfully (as he had mislaid his drawings) alluded to this peculiar arrangement. I have to thank Dr. Hubrecht for kindly sending me a specimen and fragmentary proboscis of his *Drepanophorus rubrostriatus* (a form probably identical with that of M. de Quatrefages) from Naples, and thus permitting me to clear up most of my doubts, as well as to make some additional observations.

First, then, there can be no difficulty in placing the form under the ENOPLA, since it has a proboscis furnished with stylets. It, moreover, agrees with the characters of the family AMPHIPORIDÆ, since it has rounded ganglia, the nerves placed within the two muscular layers of the body-wall, and a mouth which opens in front of the ganglionic commissures. It falls easily into the subfamily *Amphiporinæ*, for it has a proportionally large proboscis. There appears to be no objection to the institution of a new genus for its reception, though, for my own part, specific separation seems quite satisfactory. The general appearance of the Nemertean is strictly that of the *Amphiporinæ*, and it swims like *Amphiporus pulcher*.

In the remarks on the structure of the species the same order as that followed in former publications will be adopted, so that the various heads may be easily compared with those of Dr. Hubrecht,[3] who has followed this arrangement.

1. *Dermal Tissues.*

The cutis (*a*, Pl. I, fig. XIV) is well developed, and the basement-layer, *b*, is very thick, as in *Amphiporus pulcher*. M. Marion mentions,[4] with some doubt, "a structureless basilar layer," as if he were indicating a new fact; but this common arrangement has been long ago described in many members of the order. Exactly in the middle line of the dorsum, between the basement-layer and the external or circular muscular coat, is a solid band *b e* (somewhat ovoid in trans-

[1] "Aanteekeningen over de Anatomie, Histologie en Ontwikkelingsgeschiedenis van eenige Nemertinen.' Utrecht, 1874.

[2] 'Ann. Nat. Hist.,' 4th ser., vol. xv, p. 371 (from the 'Comptes Rendus,' Feb., 1875).

[3] I have to thank the Editors of the 'Quart. Journ. Mic. Sc.' for courteously forwarding a proof of Dr. Hubrecht's article, which will appear in the same Number.

[4] Op. cit.

verse section) which runs throughout the length of the body. I have not seen this arrangement in other Nemerteans, and its function is unknown. Dr. Hubrecht and M. Marion have not yet noticed it. No mention was made of "flask-shaped glands" in my descriptions of the cutaneous system of the ANOPLA, because such a termdid not appear to apply to any structure observed.

2. *Muscles of the Body-wall.*

The circular or external muscular layer in *A. spectabilis* (*c*, fig 1) presents in longitudinal section a series of definite rows, and the fasciculi have a somewhat pennate arrangement. M. Marion says they differ completely from the longitudinal fibres (in the absence of the pennate arrangement), but he can only refer to the respective appearances observed in transverse sections of the body-wall. Within the circular are two thin strata, *c e* and *c o*, which represent in a somewhat less pronounced degree the decussating layers so well seen in *Amphiporus hastatus*. Such appear to have escaped the notice of Dr. Hubrecht and M. Marion. The great longitudinal layer, *d* (fig. 1) has its fasciculi, in transverse sections, also arranged in definite though much longer rows than the circular (in longitudinal sections), groups of rows, moreover, being, as usual, marked off by somewhat regularly disposed radiating bands, which pass from the outer layers inwards to the alimentary region. Dr. Hubrecht thinks I have undervalued the "inter-fascicular substance" which he says "is a kind of fibrous connective tissue." It has been often alluded to and figured in my observations, and since an opportunity is now afforded I shall do more justice to the fibres which pass from wall to wall (emerging between the rows of fasciculi) by stating that they are muscular in many of the ENOPLA and also in many of the ANOPLA. In longitudinal vertical sections of the large *Lineidæ* these interlacing muscles map out, for instance, the great longitudinal layer into a kind of meshwork. Their connection with the hyaline and fibrous tissue of the body-cavity will be noticed elsewhere, especially in relation with the generative organs in *A. spectabilis.* M. Marion first pointed out the somewhat pennate arrangement of the longitudinal muscular layer (in transverse section) and its resemblance to the condition in the Oligochæta. The fasciculi in the Nemertean are more slender and linear as well as less regular. The linear grouping of these fibres is common in the Nemerteans, such as in *Valencinia lineformis*, *Carinella* *linearis*, and *Carinella Armandi*, but, so far as at present known, this is the only species in which such fine transverse divisions of the fasciculi have been described. It is not unlikely that the arrangement may occur in other southern Enopla. The muscular bundles are usually composed of rather coarse fibrils on transverse section, whereas in this form they are small and arranged in a pennate manner. The nearest, perhaps, is *Amphiporus hastatus*, in which both the circular and longitudinal muscular fibres are arranged in very narrow and regular rows (Pl. XIV, fig. 2), and this species further shows very complete development of the two thin decussating layers, *c e* and *c o*, outside the longitudinal coat. In many longitudinal vertical sections the impression conveyed with regard to the inner was that its fibres were more transversely placed than in the exterior stratum. *A. hastatus* is a large and powerful species, and the conditions of its existence (for it occasionally burrows in sand) may have some connection with this arrangement.

In *Lineus gesserensis* there is anteriorly a thin layer of circular muscular fibres immediately beneath the basement-layer, the pressure of which had formerly been overlooked.

3. *Proboscidian Sheath.*

The sheath for the proboscis slightly differs in muscular structure from the typical Enopla, being composed externally of circular fibres (Pl. XIV, fig. 1, *o a*) and internally of longitudinal, *o b*, many fibres of the latter, however, mixing with the circular coat, but not reaching its exterior region. Both kinds are largely developed and in marked contrast with the finely arranged and somewhat pennate fasciculi of the circular and longitudinal muscles of the body-wall. The figures of my friend Dr. Hubrecht (op. cit., Pl. II., figs. 4 and 5) appear, however, to be somewhat diagrammatic, while the remark[1] that the proboscidian sheath in *A. spectabilis* (or *Drepanophorus*) is "chiefly composed of circular fibres *intermixed* with longitudinal bundles" requires the foregoing description, and the observation that this form does not present the well-defined demarcation between the layers usually characteristic of the Enopla. Coating the internal surface of the chamber is a structure which is faintly developed in the ordinary Enopla (even in *Amphiporus pulcher*), viz., a mucous layer which presents in transverse sections (fig. 1, *oc*) a frilled or somewhat papillose aspect, the free margins being

[1] See present Number of the 'Quart. Journ. Micr. Sc.,' p. 125.

granular. This is a conspicuous feature in the form. Dr. Hubrecht has not alluded to the series of apertures situated on each side of the sheath superiorly, and which lead—by channels hereafter to be mentioned—into the vascular system.

Dr. Hubrecht says that the sheath occurred throughout the entire length of the Nemerteans observed by him. This and other remarks will not, of course, apply to the *Carinellidæ*.

4. *Proboscis.*

As already stated, my sole specimen of *A. spectabilis* on a former occasion did not permit me to describe or figure the proboscis, further than to observe that the general structure agreed with the typical forms; and that the longitudinal bands of the reticulated layer of the anterior region of the proboscis were especially apparent.[1]

Dr. Hubrecht's specimen has enabled me to supplement the hiatus to some extent, though no stylet-region is present. In structure the anterior region of the proboscis is quite typical, and though the example is everted, there is no difficulty in understanding all the relations by contrasting it with those of other species, likewise everted. Externally (Plate XV, fig. 1) there is the elastic layer, *g*, showing as usual towards its outer border some definitely formed fibres, and being often slightly granular. To judge from Dr. Hubrecht's remarks he may term this layer an external circular coat, but as longitudinal sections show only a few muscular fibres externally, the rest being nearly homogeneous (op. cit., Ray Society, p. 52), greater precision of description is required. A glance, however, at his figures will decide. Within is the conspicuous belt of the external longitudinal muscular coat, *f*, which, like the other muscular coats, is composed of very coarse fibrils—coarser proportionally than in the largest *Amphiporus pulcher* in my collection, and therefore in marked contrast with the respective appearances of the longitudinal muscular layer of the body-wall in the two species. This coat is followed by the reticulated layer, *e*, which is admirably shown in the Neapolitan form according to the interpretation formerly advanced (op. cit.[1] Ray Society, p. 52, &c.) The outer apices of the longitudinal bands (lozenge-shaped in such a preparation—after transverse section) send fibres to the outer coat of the proboscis: a few also pass towards the circular layer from the opposite angle. The coarsely fasciculated inner longitudi-

[1] Op. cit. (Ray Society), p. 64.

nal coat, *d,* comes next; then the fifth layer of circular muscular fibres, *c,* with the basement layer, b^1, and a beautiful papillose glandular lining, *b,* internally. Very fine fibres pass from the base of the glandular papillæ to the circular muscular coat. I have been thus particular in specifying the layers (or repeating, as they correspond with previous remarks) because my friend Dr. Hubrecht in a recent publication[1] has put forward views—based on the examination of this form—which diverge wholly as regards the structure and function of the reticulated layer of the proboscis of the Enopla. He considers the layer as glandular, and an inspection at his drawing (op. cit., Plate II, fig. 2) shows that a misinterpretation has occurred. If the proboscis of this or any other typical member of the Enopla be examined in the fresh condition, a number of longitudinal bands at regular intervals are very conspicuous in the anterior region. These are the thick columns (*e*) of the reticulated layer. If a longitudinal slice be taken from the proboscis of *Amphiporus pulcher* (Plate XIV, fig. 4), the same columns form a series of boldly marked longitudinal bands (*e e*) connected together by numerous transverse slips (*e′ e′*), which unite the longitudinal columns. In transverse section these bands, as already seen, completely separate the longitudinal muscular fibres of the proboscis into two layers, and in none are they better seen than in Dr. Hubrecht's specimen. The latter author, therefore, in representing (op. cit., Plate II, fig. 2), and describing the great longitudinal bands of this layer as isolated glands, had omitted to make a longitudinal section or examine the proboscis in transverse section with sufficient detail, for he overlooks the connecting bands (*e′*, *e′*,) between the longitudinal columns. In no group is it so necessary as in the Nemerteans to examine an extensive series of the animals and their organs under varying conditions, both during life and after preparations.

I am glad to see that my friend in his present communication to this Journal has now retired from the foregoing position with regard to the reticulated layer. A careful examination of longitudinal and other sections would certainly convince him. I must demur, however, to the somewhat doubtful remark that the longitudinal columns of this layer are "surrounded and united by bands of fibrous elastic tissue which at the same time traverse the longitudinal muscular coat in all directions, and originally depart from the external and internal circular layers of elastic tissue." We have already seen how this "fibrous elastic tissue" has fared

[1] 'Aanteekeningen,' &c., olim cit.

in the body-wall and body-cavity, and it is of little avail here as a help to make improvements on the interpretations already advanced. The transverse slips (*e′*, *e′*,) between the great longitudinal columns of the reticulated layer are part and parcel of that layer, and their continuity therewith causes the edges of each column in contracted specimens to assume a denticulated aspect. Moreover, they form a complete separation between the outer and inner longitudinal fibres, their only connection with the latter being perhaps the transmission of a few fibres between the fasciculi, but I have nothing to advance in support of this except the zig-zag processes on the transverse slips, seen in the everted organ (Plate XV, fig. 1, *e′*, *e′*,). Such a connection, at any rate, is of little import in the case. Dr. Hubrecht next doubts the muscular character of the circular muscular layer, (*c*, Plate XV, fig. 1), which has been found in every member of the ENOPLA examined. The figures connected with the present communication have not been seen, (he refers to "circular layers, *e f*, and *c f*"), but if a longitudinal section be made of the organ (*e. g.*, op. cit., Ray Society, Plate XI, fig. 7), he will find the cut ends of the circular muscular layer (*c*), and perhaps his "interlaced elastic tissue" between them; moreover, he will see the cut ends of the transverse slips (*e′*, *e′*,) connecting the longitudinal columns of the reticulated layer (if the knife goes between the latter columns), which with other facts show the propriety of indicating a separation of the longitudinal fibres into two layers. No sound interpretation will make the cut ends of these transverse slips in such a section appear only as the "bands of fibrous elastic tissue, which at the same time traverse the longitudinal muscular coat in all directions, and originally depart from the external and internal layer of elastic tissue," the more especially as one of the latter is a circular muscular coat (*c*). All this has already been clearly shown in former publications and drawings.

With regard to the structure of the stylet-region in this form there seems to be room for further minute investigation. Dr. Hubrecht shows (op. cit., Pl. I, fig. 3) the walls of the anterior chamber continued straight backwards of the same thickness over the stylet-region and the subsequent posterior region. It would be well to make transverse and other sections from the front of the region backwards to the posterior chamber so as to observe the change in the layers. M. Marion again states that "on each side of the bulb" of the peculiar stylet "there are eight or ten styligerous vesicles."

Dr. Hubrecht mentions that in *Meckelia somatotomus*, Leuck.

(one of the *Lineidæ*) "the curious deviation of fibres from the internal and external circular muscular layers presented a somewhat different aspect" from anything that had been described. A glance at Pl. XXIII, fig. 17 (op. cit., Ray Society), will remove doubts, for in that form (*Cerebratulus angulatus*) the fibres cross exactly at opposite poles. It would be well also that Dr. Hubrecht should make various longitudinal sections of the proboscis of the foregoing *Meckelia somatotomus* to see if the "external circular muscular layer" (*e* in his Plate II, fig. 7, op. cit.) really goes all the way round, because such is uncommon in the *Anopla*. At any rate a homogeneous elastic investment of the longitudinal layer immediately beneath is sure to be encountered.

5. *Digestive and Circulatory Systems.*

The digestive system in *A. spectabilis* agrees with that in the typical Enopla.

The vascular system shows the usual central dorsal vessel beneath the proboscidian sheath, and a ventral on each side —beneath and internal to the nerve trunk, and in addition there are numerous accessory trunks. The coloured circulating fluid in these vessels was first described in the allied species (*Cerebratulus crassus*) by M. de Quatrefages, and in the present form by Prof. Keferstein, who also mentions the corpuscles. Dr. Hubrecht and M. Marion confirm these observations. The latter, whose anatomy of the Nemerteans received attention in the Appendix (op. cit., Ray Soc., p. 213 &c.), in his most recent remarks[1] states "that the vascular apparatus of this Nemertean presents the surprising peculiarity of containing elliptical globules slightly flattened, and of a red colour identical with that of the blood-globules of man." "If we press down a part of the body, these corpuscles accumulate in certain regions of the circulatory system, and form masses of an intense red colour. The oscillations of the globules also may be followed by observing a young animal by transmitted light. The corpuscles are set in motion by a colourless liquid, in which they float without any constant direction." He then mentions a dorsal and two ventral trunks, with the transverse branches from the one to the other, but it would have been well if he had been a little more definite in his description of this course of the corpuscles in these vessels, and, moreover, if he had indicated the richly corpusculated fluid within the proboscidian sheath. If a longitu-

[1] 'Ann. Nat. Hist.,' olim cit.

dinal vertical section be made through the proboscidian sheath of this form as seen in *Drepanophorus rubrostriatus*, Hubrecht (Plate XIV, fig. 5), it is found that the wall is perforated near the dorsal curve by a definite series of apertures (*e a*) on each side—a fact hitherto unknown in Nemertean anatomy. The peculiar arrangement of the longitudinal and circular fibres, which intermix, except at the circumference, is therefore probably in relation with this condition. Attention was first directed to the subject by observing a canal passing out in transverse section, and it is probable that a similar view has caused Dr. Hubrecht to represent a lateral separation by curved fibres on each side of a transverse section in his Plate II, fig. 4.[1] The proboscidian chamber (cavity of the sheath), with its rich supply of fluids and corpuscles, thus in all probability elaborates the blood, which then enters the trunks constituting the vascular system proper. The anatomy and physiology of the proboscidian sheath, its cavity and contents, and the study of the circulatory system in the living animal, afford an interesting field for further minute investigation. The size of the definitely formed proboscidian corpuscles merits special attention with regard to their passage outwards through the lateral trunks. In the ordinary Enopla they are very large, whereas in this species they are probably smaller, unless it happens that the larger bodies remain in the sheath-cavity. The proboscidian sheaths were examined specially in *A. pulcher* and *A. hastatus*, but no trace of such apertures was visible. The coarse nature of the encircling and other fibres of these sheaths sometimes prevents certainty of examination, but though a minute aperture therein might have been overlooked, it could not have escaped notice in a section of the superficial fibres, or the translucent region immediately external (where the vessels are very conspicuous in *Drepanophorus*). In the living Enopla formerly investigated, all trace of such arrangement was absent. In ordinary transverse sections of Dr. Hubrecht's specimen there are within the longitudinal muscular coat on each side of the proboscidian sheath one or two large well-defined areas, which may be connected with this system. There are also numerous transverse vascular branches in *Amphiporus pulcher;* and in *A. hastatus* a second longitudinal trunk (Plate XV, fig. 2, *v′*) occurs above the lateral nerve.

Dr. Hubrecht observes with regard to the circulation in *Lineidæ* that he cannot agree with me "in regarding the position of these blood-vessels as quite constant." I am not

[1] 'Aanteekeningen,' &c.

aware that any such limitation was made, and the figures show very great variety in this respect. In a new *Valencinia*,[1] recently described, the changes which take place in the position of the trunks in their course from the snout backwards to the tail are very considerable, and perhaps other *Carinellidæ* may show this arrangement in a more pronounced form. It is of little importance in the *Lineidæ* to place much weight on the absolute position of the ventral trunks, but they certainly all fall under one plan.

6. *Nervous System.*

Dr. Hubrecht observes that the lateral nerve-trunks in *Amphiporus spectabilis* (his *Drepanophorus*) have considerably approached the median ventral axis of the animal. Though this is the case, the degree of change does not alter in any respect the relationship to the typical *Amphiporidæ*. He has misunderstood the remarks about the position of the nerve-trunks in the Meckelian type (Trans. R. Soc. Edin.), because, following in my earlier paper Dr. Johnston's Catalogue, *Carinella annulata* is there indicated by the term *Meckelia annulata*. He does not appear to be acquainted with the *Carinellidæ*, whose nerve-trunks occupy the position described.

Dr. Hubrecht's remarks centre round two chief points in regard to the nervous system. He states, in the first place, that the cephalic sacs of the *Lineidæ* are continuous with the ganglia, and in the present paper he has revived the views of A. S. Œrsted and others, with a little modification, that they act "as a special respiratory apparatus providing the cephalic hæmoglobin with fresh supplies of oxygen." It is curious, however, that his figure (Pl. II, fig. 8) of the organs in *Meckelia somatotomus* (one of the *Lineidæ*) shows not a trace of the ciliated ducts, which occur in all the British and foreign representatives of the family examined.[2] The intimate relation of these sacs with the ganglia is well known, but after again glancing at my preparations, and consulting the observations and drawings of the living *Lineus gesserensis* (in which the organs are most distinctly

[1] Vide 'Proceed. Linnean Soc.' 1875.

[2] Moreover, an explanation of this figure is required, since the great commissure is superior and the small inferior, while the reverse is the case in nature. In a more recent publication, with a supplementary plate, the ducts are added to the organs, but they are represented as entering the sacs superiorly in the middle line, whereas they usually enter at the inferior and outer border. The same dubious arrangement of the ganglionic commissures persists in this figure ('Niederländisches Archiv f. Zool.,' Bd. II, Heft 3, Taf. xi, f. 3).

represented), I have only to state that in the adult they appear to have their proper investment all round, except where it is indented in the preparations by the prominent posterior fibrous *cornu* of the ganglion, from which (*cornu*) each probably receives supply. Further, instead of being in doubt on the subject, I am now inclined to consider these sacs as special sense-organs. It is indispensable in such researches to examine an extensive series of favourable living forms, some of which show these organs very distinctly. Again, it is also necessary to consult those in which they are wholly absent, *e.g.*, *Cephalothrix,* as well as their appearance in such forms as develop new heads on fragments of their bodies, *e.g.*, *Lineus sanguineus.* But the most crucial evidence in support of our view that, though closely connected with the ganglia in the adult, the cephalic sacs are structures *sui generis* in *Lineus gesserensis,* is that afforded by the young animal in the course of its development. The careful examination of Pl. XXIII, fig. 9. (op. cit., Ray Society) will show those organs (*m*) very considerably posterior to the ganglia, and it is observed that their gradual advance in position, and proportional diminution in size as age increases, are interesting features. Dr. Hubrecht's remark about abnormal tension as the cause of the separation in *Lineus gesserensis* will not, I fear, apply to the various sections, horizontal, vertical, and transverse. The finding of hæmoglobin (which was formerly, and with propriety, called red colouring matter) is interesting; but as the same red colouring matter accompanies the nerve-trunks in many forms without any access to the sea-water, and as Dr. Hubrecht will probably find it in abundance in the great red muscles of the body-wall, and in the fluids of *Borlasia Elizabethæ* (op. cit., Ray Society, p. 97), some caution in predicating functionally of the cephalic sacs in this respect is necessary.

The second point under this head is Dr. Hubrecht's assertion that "*a sheath of nerve-cells,* thicker in the vicinity of the ganglia, thinner further backwards," accompanies the lateral nerve-trunks, and that I had not remarked this cellular coating. If, however, for example, Pl. XXI, fig. 6 (op. cit., Ray Society), be examined, this coating is represented as sufficiently cellular (×700 diam.). In transverse sections of large examples of the Lineidæ, nothing can be more evident than this investment of the lateral nerve-trunk, which is deeply tinted by the reddish colouring matter —a feature very boldly seen in *Borlasia Elizabethæ,* whose muscles are likewise reddish. As Dr. Hubrecht and my own drawing show, perhaps fibro-cellular would have been a better term to use in describing it. Through this investment the radiating muscles in many pass—sweeping close to the nerve-trunk in its proper sheath, as represented in the Ray Society's work (Pl. XX, fig. 13). Now, Dr. Hubrecht in his drawing (Pl. I, fig. 7, op. cit.) represents these fibres as ceasing entirely outside the sheath, and thereafter as passing only in parallel lines to the circumference of the great longitudinal muscles, and the same hiatus in regard to the nerve-investment occurs in his descriptions. The passage of muscular fibres through "hæmoglobinous nerve-cells" appears to me somewhat interesting, and in sections they would require special description. In longitudinal sections the inter-cellular substance assumes a more distinctly streaked appearance, and the tissue is loaded with granular cells of various sizes, which have been first described as nerve-cells by Dr. Hubrecht. The whole appears to be attached to the sheath of the nerve on the one hand, and abuts on the muscular layer by a somewhat better defined margin in transverse sections, the muscular fibres formerly alluded to, of course, breaking the continuity of the latter. Dr. Hubrecht thus deserves credit for the discrimination of this investment as one apparently composed of nerve-cells—continuous with the ganglionic tissue in front.

7. *Reproductive Organs and Development.*

Dr. Hubrecht observes that "eggs and sperm-sacs (*f*) take their origin between the double intercœcal fibrous septa (or dissepiments), which separate when the sexual organs begin to develop. The characteristic tubes (*g*, *g*, Plate XV, fig. 3) so distinctly seen in *Amphiporus hastatus*, as will by-and-by be shown, may throw further light on his views here, especially as indications of these are observed towards the posterior region of the specimen from Naples he kindly forwarded to me.

Lastly, I am inclined with M. Marion to think that further investigation may show some connection between the different species of Dr. Hubrecht's *Drepanophorus* and M. de Quatrefages' *Amphiporus spectabilis*. It is well to bear in mind that the latter is characterised by having branched cephalic furrows, such as Dr. Hubrecht shows in a diagrammatic form in his *D. serraticollis*. To summarize, therefore, Dr. Hubrecht's results, which he says "have often confirmed, but which have not seldom differed from and contradicted, the conclusions and views entertained" by me, we find them centre round the following details :—

1. He avers the inter-fascicular substance of the muscles had been undervalued, yet nothing of importance is mentioned by him on the subject, and less figured, and unfortunately he does not discriminate the muscularity of many of the bands he alludes to. The radiating and other muscles and bands perform important functions in the Nemerteans, passing often in a most complex manner through the layers of the body-wall to the basis-layer, as well as traversing the body-cavity.

2. He is doubtful concerning the internal circular muscular coat and the external investment of the proboscis. A single accurate longitudinal section of a suitable example would remove every trace of doubt. It is a very simple arrangement. A similar slip was made in regard to the reticulated layer, which he has now corrected, without, however, indicating how this change occurred.

3. His results under the head of *Nervous System* are two, viz., the incorporation of the cephalic sacs with the ganglia in the Anopla, and the assertion that the investment of the lateral nerve-trunks in the same group is composed of "hæmoglobinous nerve-cells." His notion that the cephalic sacs are a special respiratory apparatus for furnishing the "cephalic hæmoglobin with oxygen," is, I fear, somewhat visionary. He has the credit of clearly describing the cells in the investment of the lateral nerve-trunks.

While on these points he is prominent, he has not observed, in his own form, the two very distinct thin layers inside the circular muscular coat of the body-wall, the important apertures in the proboscidian sheath, the generative tubes, and the somewhat pennate arrangement of the muscular fasciculi; the passage of the muscular fibres though the investment of the nerve-trunks (his "hæmoglobinous nerve-cells") in the *Lineidæ*, and he is unaware of the great modifications in structure in the *Carinellidæ* and *Cephalotrichidæ*.

Some very interesting observations on a land-Nemertean from the Bermudas by Dr. Willemoes-Suhm,[1] one of the naturalists on board the "Challenger," call for a few remarks. This form (*Tetrastemma agricola*, Willemoes-Suhm) appears to be a typical member of the Enopla, and its structure, on the whole, is fairly represented, under the great difficulties which a travelling naturalist must labour in investigating an organism so soft and so complex. The absence of the cephalic sacs is peculiar and exceptional, and I should have expected them in such a form. The mouth probably opens in front of the ganglia, not behind them, the former

[1] 'Ann. Nat. Hist.,' June, 1874, vol. xiii, 4th ser., p. 409, Pl. XVII.

being invariable in the ENOPLA. The mouth in the author's figure refers to the œsophageal region. The proboscis will probably be found on transverse section to be within a proboscidian sheath, composed chiefly of external circular (or oblique) and internal longitudinal fibres, with the proboscidian corpusculated fluid in its interior. The termination of the proboscis, therefore, will not be attached to the walls of the body, but to the interior of the sheath. The sexual differences in the basal portions of the central stylet are most interesting, and the author is quite right in observing that such sexual differences have not hitherto been observed in the Nemerteans, though various varieties occur in the same form. The remarks on the habits of the species are also valuable. The commensalistic Nemertean alluded to by the author at the end of his paper is closely allied to the *Nemertes carcinophila* of Kölliker, and it probably has a similar habit of frequenting (in sheaths) the abdominal hairs of female crabs. The occurrence of lateral stylet-sacs is noteworthy. The plate accompanying the paper is probably diagrammatic, and the inversion of the figures, the inversion of the ganglionic commissures, and other imperfections, need not therefore be mentioned.

In some additional remarks on a hermaphrodite Nemertean (*Borlasia Kefersteinii*) by M. Marion,[1] he finds that the young specimens show a predominance of one sexual element, while the older forms have a nearly equal proportion of male and female elements. The male reproductive elements are developed first, and then the female. He is somewhat in doubt about the connection of the ovaries and sperm-sacs with surrounding parts—mentioning that they occur without order in the general cavity of the body, and that they have a short peduncle apparently in connection with the lateral vessel. This is scarcely accurate, for the sexual organs have no connection with the lateral vessel, the contents finding exit above the nerve and vessel. He again alludes to the spermatozoa being liberated in April into the general cavity of the body, another misapprehension, since the proboscidian canal (cavity of the sheath) and the digestive tract are the only general cavities within the body-wall. He probably means the region between the body-wall and the alimentary canal, but there is no space there, only the ovaries and the sperm-sacs. There is nothing new in his observations on the young animals. Whether the spermatozoa impregnate the ova without passing into the surrounding water, or after diffusion through that element, has not been ascertained in this form; but the latter would seem very

[1] 'Ann. des Sc. Nat.,' 6e sér, Zool., tom. i, pp. 19, &c.

probable. The water at any rate—judging from analogy—must be loaded with ripe spermatozoa in vast multitudes.

In a very fine *Amphiporus hastatus* from Southport sands (in October) I was struck by observing in longitudinal sections a somewhat regular arrangement of cut cellular tubes. This appearance is due to a series of tubes filled with granular nucleated cells (Plate XIV, Fig. *3, g, g*), which pass downwards at tolerably regular intervals from each side of the proboscidian sheath, and terminate at a fissure of the longitudinal muscular coat a little above the nerve-trunk. Similar tubes curve along the ventral surface beneath the alimentary chamber, and terminate at the same points (*g'*). The enormous number of these cells show that if they are ova the majority become absorbed as development proceeds; but of course this is conjecture. Investigations on the living animals will show the importance of these organs in the physiology of reproduction. As indicated formerly, a similar tendency was observed in the posterior part of Dr. Hubrecht's specimen, which anteriorly was distended with spermatozoa.

The *Pelagonemertes Rollestoni* of Mr. Moseley,[1] of the "Challenger" expedition, occurred near the southern verge of the South Australian current, and in all probability will be found to be one of the Enopla, if the author is accurate in affirming that the mouth opens in front of the ganglia, and the external muscular fibres of the body-wall are circular and the internal longitudinal. The digestive canal is generally more or less pinnate in the Enopla, and characteristically so, for example, in *Nemertes gracilis*.

The elaborate paper on the histology of the land Planarians of Ceylon in the 'Philosophical Transactions' for 1874, by the same author,[2] forms an important contribution to our knowledge of the subject, and as *Bipalium* was examined when treating of the homologies of the Nemerteans, a comparison of the observations may be useful.

In regard to the hypoderm or cutis (his epiderm), Mr. Moseley observes that it alters its character on each side of the ambulacral line, and "becomes far thicker and apparently less definite in structure." In my specimens (for which I have to thank Dr. Percival Wright), the mass of the cutis (or hypoderm) was much thicker and denser on the dorsum, more translucent on the ventral median ridge, and the layer, as indicated by the basis-structure, decidedly narrower. The region above is certainly greatly hypertrophied. The hypoderm

[1] 'Ann. Nat. Hist.,' March, 1875, p. 1, Plate XV, B.

[2] I have to acknowledge the courtesy of Prof. Rolleston in kindly procuring me a copy of this paper during the absence of the talented author in the "Challenger."

(cutis) is here bounded by a distinct basement-structure, for most of the circular muscular fibres have spread out to cross the region transversely some distance inwards. The basis-layer is extremely indistinct in contrast with that of the Nemerteans—both in transverse and longitudinal sections, and no allusion was made to it in the general remarks in connection with the Nemerteans. Mr. Moseley's fine preparations, however, probably show it more satisfactorily. His observations having again drawn attention to the subject, it is found that in longitudinal sections (where it ought to come out boldly) careful examination indicates a termination of the hypodermic layer outside the circular muscular coat. That such a basis-layer, however, should fail to be the homologue of the basis or basement-layer in the Nemerteans and Planarians is peculiar; the more so, as Mr. Moseley makes the circular muscular layer (immediately beneath) the homologue of the basis-layer in the Nemerteans and Planarians. "Great stress," he says, "has been laid by various authors on the supposed fact, that whilst in Annelids, Nematoids, Trematodes, and, in fact, all higher worms, the external coat of the body was arranged circularly and the internal longitudinally, in Turbellarians the reverse was the case; and the statement has been made in such a form that it really appeared as if an inversion of the muscular coats must be supposed in order to get at the proper homological relations of the muscular structures." "M'Intosh lays great stress on the fact, that in *Ommatoplea alba* the circular muscles are external and the longitudinal internal, whilst in *Borlasia* the reverse is the case; and accordingly he regards these two worms as belonging to very different types indeed."[1] I certainly (and with greater emphasis) still regard the *Amphiporidæ* and *Lineidæ* as very different types of Nemerteans; but, as before, this is based upon much more extensive data than the muscular system. The statements are not dependent on any theory, which, I fear, is the case with the view of the homology of the circular muscular fibres of *Bipalium* with the basis-layer of the Nemertean body-wall. Further, he observes—"But the external circular coat of *Ommatoplea* is evidently the homologue of the thick external tunic of *Borlasia,* called by M'Intosh the basement membrane, since in *Ommatoplea* there is said to be no basement membrane, and the external circular muscular coat lies immediately beneath the epidermis, as does the so-called basement membrane of *Borlasia.*" An error has evidently occurred here—probably due to the printer and the absence of Mr. Moseley, because it will be

[1] Loc. cit., p. 310.

at once found[1] that a very distinct basis-layer is described and figured both in *Ommatoplea* and *Borlasia;* and, moreover, I consider that—for the matter of homology—there is no need to go beyond this structure (basis-layer) in the forms just named and in *Bipalium*. Mr. Moseley thinks the basis-layer performs the part of a muscular tunic in the Nemerteans and Planarians, but as these animals are already sufficiently provided with muscular layers, it can only act as an accessory and very efficient *elastic* investment (probably after the manner of the cuticle in the Annelida). It is often observed to be frilled while the subjacent circular muscular coat in the ENOPLA is straight. I have further to add that the late Professor Keferstein was right in saying that the pigment in many Planarians disappears in alcohol, and is much altered in others. The black pigment of the eye-specks, however, as Mr. Moseley observes, remains.

The description of the primitive vascular system of *Bipalium* is novel. Mr. Moseley observes that it has the form of a spongy vascular tissue, and, moreover, has the nervous system in its interior in the form of a "meshwork" "very indistinctly differentiated histologically." My slight examination had resulted in doubt as to the nature of this pale area,[2] for in no preparation was there any appearance to support the "vascular" idea, neither could any nerve-elements be observed. A re-examination gives no grounds for a more decided expression of opinion. Further, the dissections of the ordinary Planarians for comparison with the Nemerteans lend no support to Mr. Moseley's statement that a similar "primitive vascular system" exists in them near the oviduct. I still agree with Prof. Keferstein's view that much more extensive observations both in the living and preserved Planarians are necessary before such can be accepted as a "primitive vascular system."[3] Finally, nothing has been seen to substantiate the notion that the ganglia of the Planarians lie within a "primitive vascular sinus." Indeed, I am bound to say that such a view is wholly opposed to my experience both in the Planarians and Nemerteans.[4] In not a few of the latter two muscular layers intervene between the vascular and the central nervous systems; and, if in either group a pale area surrounds the ganglia, it is widely different from "spongy vascular tissue." The nerve-cells of the Planarian ganglia are exceptionally large and distinct, and they are well represented by Mr. Moseley.

[1] 'Trans. R. S. Edin.,' vol xxv, p. 308, pl. iv.

[2] Op. cit., Ray Soc., p. 143.

[3] Ibid., p. 141.

[4] The condition of the cephalic sacs and the pre-ganglionic meshes at the proboscidian canal in the Lineidæ do not affect this opinion.

NOTES AND MEMORANDA.

Haeckelina, a new gigantic Moneron.—The arenaceous Foraminifer described under the name of 'Haeckelina' in the last number of the 'Jenaische Zeitshcrift,' by Dr. Emil Bessels, is, we understand from Dr. Carpenter, identical with his form of the Astrorrhiza of Sandahl noticed by him in the 'Proceedings of the Royal Society,' June 17th, 1869.

The Tabulata not Hydroids.—A memoir may be shortly expected from Mr. Moseley, of the Challenger expedition, on the structure of Heliopora and other Tabulata, the result of his studies of these organisms in the living and fresh state. The result of these investigations is to show that the Tabulata are peculiarly modified (degenerate) Alcyonarians, with a compact stony (instead of a spiculate) skeleton.

Möller's Diatom Slides.—Herr Möller, of Wedel, the well-known preparer of diatoms, proposes to publish by subscription his methods of preparation. His *Typen-platte* and *Proben-platte* are remarkable specimens of ingenuity.

Proceedings of Societies.—Owing to the pressure of important memoirs, we are compelled to defer till our next number a large accumulation of Reports of Societies, including the Dublin Microscopical Club, Medical Microscopical Society, Liverpool Medical Institution, &c.

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

BOTANY.

Sexual Reproduction of Thallophytes.

I.

The theory of descent has given—as it has done to every other branch of Biology—an entirely new interest to the study of the lower Cryptogams. They represent forms which if not actually identical with those possessed by the remote ancestors of the more complex plants have probably not been very distantly removed from these ancestral forms by subsequent modification.

It is natural, therefore, to seek amongst the non-vascular cryptogams for indications of phylogenetic relationship. But any examination for such a purpose must of course be unsatisfactory which is not based on a sufficient knowledge of the life-histories of the different types. Without this it is impossible to compare them one with another at stages when such a comparison is really significant.

Unfortunately from the necessity which is constantly imposed upon the systematist of classifying organisms of all kinds without being able to fulfil such a condition, the most erroneous juxtapositions are constantly made, and although an immense body of accurate observations has been accumulated about different types of the lower cryptogams, it is only lately that anything like a real cohesion has been visible amongst the accumulated facts. In the fourth edition of his 'Lehrbuch der Botanik,' published towards the end of last year, Sachs has proposed and adopted a classification of the non-vascular cryptogams which, while widely differing from any which had been previously suggested, for the first time affords something like an intelligible view of their morphological evolution.

II.

The division of the vegetable kingdom into the two regions of Thallophyta and Cormophyta was proposed by Endlicher in 1836. The groups are still valid, though it is by no means easy to frame characters which will satisfactorily limit them. Except perhaps the absence or presence of the "opposition of stem and root," none of the distinctions which Endlicher pointed out are available now; least tenable of all is the absence of sexuality in the *Thallophyta.*

The classification of the vegetable kingdom by A. P. De Candolle into VASCULARES and CELLULARES (1813) is far inferior to Endlicher's, though still in use. The two terms do not properly contrast, and the inclusion of the *Muscineæ* among the *Cellulares* is entirely unnatural in the light of our present knowledge.

For the last half century the *Thallophyta* have been held to fall into the three district groups of *Algæ, Fungi,* and *Lichens;* these were first limited as they now stand by Bishop Agardh ('Aphorismi Botanici,' 1821).

The autonomy of the *Fungi* had been recognised by the oldest systematists, and as early as 1583 Cæsalpinus included under that head at any rate the larger forms which are so designated now. But *Algæ* down to the time of Linnæus were mixed up with Hydrozoa, Actinozoa, and sponges. The group, since so-called, was established by him in 1735; but while he purged it of *Lithophyta* he retained in it *Hepaticæ,* Lichens, and *Rhizocarpeæ.* Jussieu (1789) separated the *Hepaticæ,* and his Algæ consisted of the plants at present recognised as such together with Lichens.

Considered as mere convenient assemblages or depositaries to which plants might be referred, the division of *Thallophyta* into *Algæ, Fungi,* and *Lichenes,* has worked tolerably well. And although it was found impossible to characterize the groups morphologically in the vast proportion of cases, little difficulty was found in referring any particular Thallophyte to some one of them. Berkeley and Lindley (1845) found themselves obliged to limit them by physiological characters: *Algæ,* generally speaking, they regarded as aquatic; *Fungi* and *Lichenes* as aërial. The former, however, drew their nutriment from their substratum, while the latter obtained it from the air.

This classification was adopted without question until 1868, when Prof. Schwendener, of Basle, propounded his now famous theory, that Lichens are not autonomous but composite organisms, consisting partly of an alga, partly of a fungus which forms a filamentous network in which the cells of the alga ("gonidia") are imprisoned. While the latter is probably identical with forms met with in a free state the fungoid part of the lichen is only known as a parasite. In the volumes of this Journal for the last two years[1] notices will be found of all the more important papers in which

[1] 'Quart. Journ. Micros. Science,' 1873, pp. 217, 235; 1874, p. 151.

Schwendener's view has been discussed. The general result has certainly been to confirm it. Lichens must, therefore, be degraded from their position as a principal division of Thallophytes and be referred to ascomycetous Fungi as a characteristic group of parasitic forms.

In 1872 Cohn[1] went a step further in abolishing the division of Thallophytes into Algæ and Fungi—the two groups which survive after the reduction of Lichens. But, as Sachs points out, the characters which Cohn employs in establishing new groups are of quite unequal value, being sometimes morphological, sometimes physiological. There can be no real comparison of such groups as *Zygosporeæ, Tetrasporeæ,* and *Zoosporeæ.*

The classification which Sachs himself has proposed is not open to this objection, being based upon the progressive differentiation of the reproductive organs. It is obviously, therefore, a classification which, on the one hand, has only been rendered possible by modern investigation, and, on the other, is subject to continual correction. He has followed Cohn in attaching little value to the separation of *Algæ* from *Fungi.* He points out that each of these assemblages of organisms may be arranged as a morphological series which runs parallel with the other. The essential distinction between them reduces itself to a difference, which, amongst higher plants, is regarded as an adaptive one. Algæ are Thallophytes in which chlorophyll is present; Fungi are Thallophytes in which it is absent. Cohn and Sachs have attached no more importance to this than is done in the case of Phanerogams. The saprophytes *Corallorhiza innata* and *Epipogium Gmelini* hold their proper systematic position amongst *Orchidaceæ* quite irrespectively of the fact that they are as destitute of chlorophyll as an *Agaricus.* The parasitic Phanerogams are also distributed amongst the forms with which they possess morphological relationship, and are not placed apart in any special group solely on account of their physiological peculiarities.

III.

The fundamental difference between plants and animals resolves itself into a difference of nutrition. Animals are capable, plants are incapable of the ingestion of solid food. A process of *digestion,* by which nutritious material may be reduced from the solid to the liquid form, is therefore necessary to animals, unnecessary to plants. The morphological

[1] Hedwigia, 1872, p. 18; 'Journ. of Bot.,' 1872, p. 114.

adaptations which nutrition requires are in the highest degree complicated in the one kingdom, while they always remain tolerably simple in the other. Of the two functions, therefore, which divide between them vegetable life, reproduction —by which of course sexual reproduction is meant—becomes in the case of plants of far greater morphological importance than nutrition.

The following brief sketch of the rise and progress of our knowledge of the sexual reproduction, more especially of Thallophytes, is instructive as showing how much more influence on the whole a deductive method of investigation has had than an inductive. It is true that we can see now that but little real progress could in any case have been made without modern microscopes. But an equally essential condition was that investigation should be carried on without preconceived ideas, and it is impossible to look through the literature without seeing that generally it was felt to be much more important to make structural arrangements agree with theory than to try to ascertain their real nature.

The phenomena of sexual reproduction in plants was more or less familiar to even classical writers on natural history. Pliny was aware that the female flowers of the Date could not produce fruit unless the "pulvis maris" had been scattered upon them from neighbouring trees. But in modern times the first distinct recognition of the sexuality of plants is generally attributed to Sir Thomas Millington, Savilian Professor at Oxford, who in 1676 communicated his ideas as far as flowering plants are concerned in conversation to Grew.[1] Sprengel considers that to Bobart, "overseer of the physick gardens at Oxford," belongs the credit of having, in 1681, first actually demonstrated experimentally (on *Lychnis dioica*) the function of pollen. The account is given in Blair's 'Botanick Essays' (1720), p. 243, but it must be confessed it is not very conclusive. The experiments of Camerarius (1694), a professor at Tubingen, upon hemp and some other plants, were much more to the point. The sexuality of flowering plants was further developed in England by Samuel Morland (1705), and in France by Geoffroy (1711), and Vaillant (1718). The discovery was very soon over-generalised; from this time till the end of the eighteenth century most of the writers on structural botany deserve the censure passed by Sprengel[2] on Micheli (1729): "quod ubique partes duplicis sexus invenisse fingeret."

[1] 'Anatomy of Plants,' p. 171.

[2] 'Historia rei herbariæ,' vol. ii, p. 232.

Micheli described the apothecia of Lichens as flowers, and the asci as stamens. Hedwig (1783) laid the foundation of an accurate knowledge of the sexual reproduction of mosses, but thought that the function of anthers was performed in Ferns by the hairs on the back of the midrib of the fronds, while in Fungi it was accomplished by the velum.

Such views, as Decaisne and Thuret pointed out in writing on the reproduction of *Fucus,* being based only upon hypothesis or imperfect observations, fell later on into deserved neglect. A reaction began against the application of the doctrine of sexuality to the lower plants. Gmelin (1760) thought that in descending through the vegetable series the diversity of the sexes gradually diminished, till in Fuci a point was reached where fructification took place without fertilization at all. Gaertner (1788) held that the spores of the greater part of the algæ (including the Florideæ) were not true seeds, but "gemmæ." In *Fucus* he believed that the "uterus" (conceptacle) accomplished the fertilisation of the enclosed spores.[1]

At the beginning of the present century the reaction against the belief in the sexuality of the lower plants reached its climax. Endlicher made the absence of sexes, as has already been noticed, one of the distinguishing marks of Thallophytes; Schleiden, in his 'Grundzuge' (1845), ignores, as far as possible, any facts which seem to point to the existence of sexuality amongst them. But even Schleiden could not have shut his eyes to actual demonstration, and his attitude shows that the sexuality of the Thallophytes up to his time had, in reality, been rather inferred than actually proved. The whole of our present knowledge, in fact, rests on the researches of the last thirty years.

Linnæus first made use of reproductive organs as a basis of classification in his 'Systema à Sexu' published in 1735. Sprengel[2] remarks that, a little while before this, when only twenty-three years old, "lectione Vaillantii et Blairii incensus sexualis systematis fundamenta ponere cœpit."

In its essential features sexual reproduction implies the fusion of two individualised particles of protoplasm. De Bary (1858) was the first to point out in his memoir on the *Conjugatæ* that this process exists in its most generalised form in "conjugation." This phenomenon had long been known in the

[1] "Palam est .... quod in *Fucis* genuinis .... ipse uterus sua fœcundet ovula, et quod ille ipse, officia genitalium utriusque sexûs, præstet solus" ('De Fructibus,' p. xxxiii).

[2] 'Historia,' vol. ii, p. 323.

fresh-water algæ, but even in the eyes of Schleiden it was quite void of significance—an "inessential" process. Yet it is obvious that it may be regarded as identical with fertilisation if we suppose that the two elements which are necessary to take part in it are still *undifferentiated;* the two conjugating elements are indistinguishable, and have not assumed the forms and attributes of oospheres and antherozoids, of germ-cells and sperm-cells.

If we take the processes of reproduction in *Vaucheria* or *Saprolegnia* as representative, those of the *Conjugatæ* and *Zygomycetes* may be compared with them as belonging to a simpler and probably primitive type. In each case a spore is produced as the result of the confluence, in the latter of similar, in the former of dissimilar elements. We may conveniently term this spore a zygospore in the one case, an oospore in the other. The researches of Thuret, Bornet, Tulasne, and Janczewski have further shown, that in all the higher Thallophytes the effects of fertilization are not limited to the production of a single spore, but set in action complicated processes of growth which give rise to structures of great diversity, including a great number of spores, and these may be called carpospores.

From the point of view of the reproductive process we may therefore classify the mass of Thallophytes, as Sachs has done, with more or less certainty, into three large groups—Zygosporeæ, Oosporeæ, Carposporeæ. When this is accomplished it is found that in each group we have a series of Algæ associated with a parallel series of Fungi. It only remains to throw into a fourth group, Protophyta, the organisms in which from their low degree of differentiation it seems probable that sexual reproduction has not made its appearance.

The following pages contain, under the four classes established by Sachs, a brief account of the present state of our knowledge of the sexual reproduction of Thallophytes.

Class I. Protophyta.

In this class—which is to a certain extent no doubt provisional—those organisms are placed in which as far as is at present known spores are only formed by the segmentation of the protoplasm of a single parent cell (asexual reproduction) and not as the result of the fusion of segments of protoplasm derived from two distinct parent cells.

Cyanophyceæ.—This includes the same assemblage of organisms which Rabenhorst has classified as *Phycochromophyceæ.* The protoplasm of their cells is destitute of a nucleus, and besides containing chlorophyll is tinged with the peculiar blue colouring matter, phycocyan. The subordinate families are *Chroococcaceæ*,[1] *Oscillatoriaceæ*, *Scytonemeæ*, *Nostocaceæ* and *Rivulariaceæ*.

PALMELLACEÆ differ principally from *Cyanophyceæ* in the absence of an obvious blue colouring matter masking the chlorophyll. Some genera, as *Glœocystis* and *Tetraspora* develope zoospores. Like *Protococcus* and *Pleurococcus* these will probably have to be removed to the *Zygosporeæ*.

EUGLENEÆ must be placed in this group; they are not known to possess a sexual reproduction, otherwise they might be associated with *Pandorineæ* in the next class.

Fungi contribute to the *Protophyta* the group of *Schizomycetes*[2] (Bacteria), which have some affinity with *Oscillatoriaceæ*[3] and in some respects with *Saccharomyces* (yeast).

Class II. ZYGOSPOREÆ.

We here meet with the simplest mode of sexual reproduction—conjugation. In some cases an incipient differentiation of the two conjugating elements may be noticed as in *Pandorina* and *Zygnemeæ*. Indeed, in all the series there is probably a disposition to progress towards the degree of differentiation which belongs to the *Oosporeæ*.

Two divisions may be conveniently made according as the conjugating cells are motile or non-motile.

A. *Conjugating cells motile.*

Amongst the green algæ the number of forms in which the zygospore has been ascertained to be produced by the conjugation of two zoospores is gradually receiving additions. In all these cases it may be stated more or less generally that the zoospores which are produced by the successive segmentation of the protoplasm of a *vegetative cell* are of two kinds which have been named respectively *macrozoospores* and *microzoospores*. While in some cases it would appear as if the difference between these merely depended on the degree to which the successive segmentation of the contents of similar cells is carried, in others the different kinds of zoospores are produced from different kinds of filaments or perhaps even from different individuals.

The function of the macrozoospores is purely vegetative.

[1] Bornet has figured the spores of *Glœocapsa*, 'Ann. des Sc. Nat.,' 5e sér., tom. xvii, Pl. 16, fig. 3.

[2] On "Bacteria," see 'Quart. Journ. Mic. Sci.,' 1873, p. 156.

[3] On "Saccharomyces," see 'Quart. Journ. of Mic. Sci.,' 1875, p. 142.

They come to rest, "germinate," and so reproduce asexually the parent plant.

The function of the microzoospores, on the other hand is sexual. They conjugate and the zygozoospore (Areschoug), after passing into a resting phase, no doubt, also reproduces the parent plant.

The following are the cases in which up to the present time the conjugation of zoospores has been observed.

PANDORINEÆ (*Dyer*).—*Chlamydomonas* is a microscopic organism which consists of a green protoplasmic mass with a lateral speck of red pigment, varying in form from ovoid to globular and furnished with two or four vibratile cilia, attached at a hyaline apex where the green colouring matter is more or less absent. It is bounded by a delicate closely applied cellulose wall; *Chlamydococcus* only differs in the wall being separated from the green contents by an interspace. By division into two or four each individual *Chlamydomonas* gives rise to macrozoospores which eventually attain the same size and appearance as the parent. Occasionally, however, the division proceeds further, and eight daughter cells are produced—the microzoospores. Rostafinski[1] first observed that these microzoospores conjugated. Two of them touch by their colourless extremities and then gradually fuse together, eventually producing a cell with a rounded contour, but with eight cilia and two lateral pigment spots. The colourless apex of this zygozoospore soon disappears; the eight cilia follow and the zygozoospore passes into the resting condition. After having been allowed to dry up and then again moistened it gave rise—not to new zoospores, but to vegetative forms arising from repeated cell division and referable to the genus *Pleurococcus*.[2]

[1] "Beobachtungen über Paarung von Schwärmsporen," von J. T. Rostafinski, 'Botanische Zeitung,' 1871, p. 785.

[2] If we follow the example of Bornet ('Ann. des Sc. Nat.,' 3e sér., tom. xvii) and unite *Pleurococcus* with *Protococcus*, we shall then have an intelligible view of the complete life-history of a type the name of which is at any rate a very familiar one.

Rabenhorst ('Flora Alg. Aq. Dulc.') maintains *Pleurococcus vulgaris*, Menegh., and *Protoccus viridis*, Ag., not merely as distinct species, but as belonging to separate families—the former to the *Palmellaceæ*, the latter to the *Protococcaceæ*. At the same time he remarks with regard to *Protococcus viridis*, "fieri potest ut *Pleurococci vulgaris* status pro ratione loci natalis siccioris sit." *Pleurococcus vulgaris* may probably, therefore, be regarded as a more actively vegetative condition of *Protococcus viridis*, the only real difference between the two being, that one undergoes cell-division, while the other does not. As *Chlamydomonas Pulvisculus*, after the conjugation of its zoospores, develops into a *Pleurococcus*, it also may

A supposed conjugation has been described by Velten[1] in *Chlamydococcus*. But according to his observations the macrozoospores and not the microzoospores took part in it. Rostafinski[2] accordingly concludes from this and other abnormalities which occur in Velten's account that he had mistaken for conjugation the destruction of a cell of *Chlamydococcus* by a parasitic monad.

Pandorina was the plant in which the conjugation of zoospores was first described by Pringsheim.[3] He distinguishes it from *Eudorina* with which English writers have generally identified it. According to him it consists of a colony of sixteen zoospores, each of which may give rise to new colonies by division. This is the asexual mode of reproduction. The first stages of the sexual condition are very similar. But in the final result the new colonies resolve themselves into their constituent zoospores which are frequently eight instead of sixteen in number. They vary in size, but though there are zoospores that are comparatively large, and some which are small, there are others which correspond to every intermediate dimension. Pringsheim considers that this difference of size indicates a certain amount of sexual differentiation. For usually a small zoospore (antherozoid) conjugates with a large zoospore (oospore). When the zoospores which conjugate are equal in size they possess the mean dimensions; these might be regarded, therefore, as sexually undifferentiated. The largest sexual zoospores never conjugate with one another.

In *Pandorina* it must be borne in mind that size ceases to be a criterion of difference between the vegetative zoospores (macrozoospores) and the sexual (microzoospores).

The phenomena of conjugation repeat what has already been stated in *Chlamydomonas*. The sexual zoospores, according to Pringsheim, appear to seek out and approach one another in pairs. They touch by their transparent anterior extremities, blend at these points, and eventually form a united body geminate in shape. The double notch, which indicates the original distinctness of the two zoospores, gradually disappears, and the zygozoospore assumes a rounded form which gives no indication of its composite origin, except that its anterior extremity has two lateral

be referred to *Protococcus*, of which it may now be regarded as the motile condition.

[1] 'Bot. Zeit.,' 1871, p. 383.

[2] Ibid., 1871, p. 788.

[3] "Ueber Paarung der Schwärmsporen," Pringsheim, in 'Monatsber. der Berliner Akad.' Oktob., 1869.

red spots and four cilia. Both red spots and cilia subsequently disappear; the zygozoospore passes into the resting condition, and eventually gives rise to a new *Pandorina* colony. The whole process of conjugation occupies at the most five minutes.

With respect to other forms allied to *Pandorina* our knowledge is far from complete. In *Gonium* the formation of microzoospores is unknown. In *Stephanosphæra* they have been described by Cohn and Wichura,[1] but their conjugation has not hitherto been seen. In *Eudorina* and *Volvox,* to which *Volvocinaceæ* is here restricted, the sexual process has attained a higher degree of differentiation and will be referred to further on.

HYDRODICTYEÆ.—The well-known fresh-water alga *Hydrodictyon* is in many respects nearly allied to the *Pandorineæ*. The contents of the individual cells undergo separation into macrozoospores and microzoospores. Of the former from 7000 to 20,000 are produced, of the latter from 30,000 to 100,000. The swarming of the macrozoospores takes place entirely within the mother-cell, and the "net," which is finally set free by its rupture, is the aggregate of these which has reached the resting condition. The microzoospores, on the other hand, are set free, and their ultimate destination is not properly known. According to Pringsheim[2] they are intended to reproduce the plant in a future season. It is highly probable, therefore, that they undergo a process of conjugation (although, as Sachs remarks, this has not yet been observed); and this may be the real meaning of the double spores which Cohn long ago figured,[3] but which he explained as the result of a casual adhesion or gluing together of two microzoospores adjacent to one another in the mother-cell. On this view the "Doppelspore," which Cohn figures, would be the zygozoospore (fig. 1).

FIG. 1.—Microzoospores (one with two cilia) and 'doppelspore' of *Hydrodictyon* × 500 (after Cohn, l. c.).

Cohn[1] also observed double spores in *Cladophora* (fig. 2), and Thuret in *Enteromorpha,* in both of which genera, as

[1] See 'Quart. Journ. Micr. Sci.,' 1858, p. 136, Pl. VI, figs. 26, 27.
[2] See Quart. Journ. Mic. Sci.,' n. s., vol. ii, p. 54.
[3] "Untersuchungen über die Entwickelungsgeschichte der mikroskopichen Algen und Pilze von Dr. F. Cohn." 'Nov. Act. Acad. Nat. Cur.,' vol. xxiv (1854), pp. 225, 226. Tab. 19, fig. 14.

will be seen below, conjugation is now known to take place. Amongst the multicellular green algæ (*Nematophyceæ,*

Fig. 2.—Conjugation of microzoospores of *Cladophora glomerata* × 500 (after Cohn, l. c., tab. xx, fig. 26).

Rabh.) the formation of zygozoospores has recently been determined in a considerable number of species.

Ulothrichaceæ only differ from *Confervaceæ* in their filaments never branching and being composed of very short cells. There seems to be no really valid ground for separating them in these respects.

Hormiscia.—Cramer[1] discovered the conjugation of the microzoospores in 1870 in *H. zonata,* Web. and M. (*Ulothrix zonata,* Kutz.). Some cells of this species produce two to eight macrozoospores, others sixteen to thirty-two microzoospores. The details of conjugation agree in every respect with what Pringsheim has described in *Pandorina.*

Urospora.—Areschoug[2] distinguishes this genus from *Hormiscia* by the presence of only two cilia on the zoospores in place of four. He has described the formation (fig. 3)

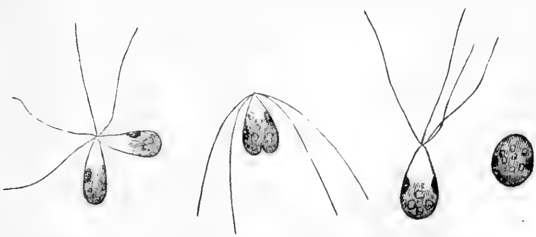


Fig. 3.—Conjugation of microzoospores of *Urospora penicilliformis* × 1000 (after Areschoug, l. c., tab. i, figs. 4-6).

of the zygozoospore (first noticed by him in 1863) in *U. penicilliformis* in the following vivacious language :—

"Microzoosporas celeriter natantes cum intuemur, duas

[1] "Naturf. Gesellsch. in Zürich," Marz, 1870; 'Bot. Zeit.,' 1871, pp. 76, 89. For the development of the zoospores, cf. Braun, "Rejuvenescence in Nature," 'Ray Soc.,' pp. 148, 159.

[2] 'Observationes Phycologicæ,' Act. Reg. Soc. Sc., Ups., 1874.

videmur sæpenumero microzooporas, quarum altera alteram fugientem persequitur. Haec est microzoospora fœminea, quæ illam, seu microzoosporam masculinam, effugere tendit, quæ contentio, quamquam nonnunquam prospera, est tamen plerumque inanis. Tunc microzoospora masculina rostrum suum rostro microzoosporæ femineæ infigit, quo facto utraque rostris cohæret. Corpus huc et illuc jactans, microzoospora fœminea se liberare conatur, spe autem fracta, utraque cursum celerrime iterat. Hoc in cursu lateribus earum adpositis, ab rostris versus extremitates earum sensim adglutinantur, ut denique copulatione absoluta, adsit zoospora, e duabus microzoosporis sexualibus composita, quattuor ciliis ornata et utrinque lateraliter granulo fusco-rubro insignita quam zygozoosporam nominare licet" (p. 3).

In this plant the macrozoospores and the microzoospores are produced by different filaments, those producing the latter being narrower. The formation of macrozoospores also takes place during the summer, while that of the microzoospores occurs during spring.

Confervaceæ. — Areschoug has detected conjugation (fig. 4) in *Cladophora sericea.* His observations lead to the

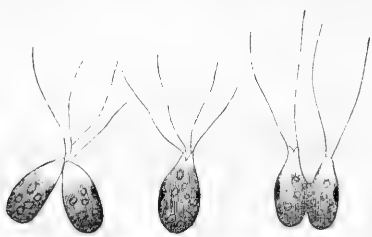


Fig. 4.—Conjugation of *Cladophora sericea* × 1000 (after Areschoug, tab. ii, fig. 12).

conclusion that the macrozoospores (also first detected by him) and the microzoospores are produced by different plants. The microzoospores are not all of the same size. "Microzoospora feminea et masculina nunc ejusdem magnitudinis, nunc masculina quam feminea minor" (p. 9).

Ulvaceæ.—Thuret first described the macrozoospores and microzoospores in this group. In *Enteromorpha* the former are furnished with four cilia, the latter with two. The formation of the zygozoospore in *E. compressa* has been repeatedly seen by Areschoug and takes place in a manner in no respect differing from that already described.

Myxomycetes.—Amongst fungoid types Sachs associates these with the groups which have been enumerated above.

This at first sight may seem surprising. Zoospores, however, are masses of protoplasm whose conjugation has many important features of resemblance to the formation of plasmodia. The cell-wall of zoospores is feebly developed, or at any rate offers but little valid resistance to the fusion of two individuals. The spores of the *Myxomycetes* set free their protoplasm as uniciliate zoospores which gradually lose their characteristic form and become amœboid. The amœbæ being destitute of any cell-membrane readily run together in a kind of wholesale conjugation and produce a plasmodium—a kind of compound zygospore, which eventually passes into a resting state and by processes more or less complicated developes the spores.

CHYTRIDIEÆ.—In the 4th edition of his 'Lehrbuch,' p. 256, Sachs suggests the propriety of placing this group in juxtaposition with the *Myxomycetes*, as it would be probably found that the zoospores conjugate. This has been actually found to be the case by Sorokin[1] in a form described by him as *Tetrachytrium*. *Chytridieæ* may occupy an intermediate position between *Myxomycetes* and *Saprolegnieæ*.[2]

PROTOMYCES is a parasitic fungus of obscure affinity. It produces sporangia which discharge with considerable force their contained spores. These conjugate in pairs to form a zygospore.[3]

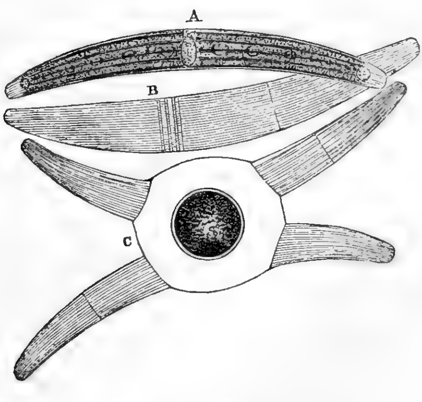


FIG. 5.—*Closterium striolutum*. A, before; B, after; C, in conjugation (after Ralfs).

[1] See 'Quart. Journ. Mic. Sci.,' 1874, p. 298.
[2] See Sachs, 'Traité de Bot.,' traduit par Van Tieghem, p. 382.
[3] See De Bary, 'Beitr. z. Morph. d. Pilze,' Hft. i.

B. *Conjugating-cells non-motile.*

Desmidieæ.—In 1836 Morren[1] published his account of the conjugation of *Closterium* (fig. 5), and was therefore the first discoverer of this process amongst the *Desmidieæ* as now constituted. This important observation had as Morren himself remarks for its not least important result the final separation of the species of *Closterium* from the animal kingdom to which they had been supposed to belong. They were seen to agree in essential points notwithstanding their curious motility with the filamentous *Conjugatæ*, which no one ever doubted to be true plants.

Diatomaceæ.—It was not till 1847 that Thwaites discovered conjugation (fig. 6) in this group which in many respects runs parallel with *Desmidieæ*.

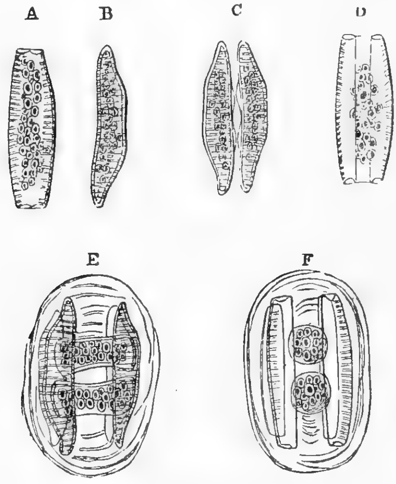


Fig. 6.—Conjugation of *Eunotia turgida* with formation of two zygospores. A, front view of frustule; B, side view; C, side view of frustules, conjugation commencing; D, front view; E and F, side and front views after formation of zygospores (after Thwaites).

Zygnemaceæ.—Conjugation was discovered much earlier in the filamentous forms. It was first observed by O. F. Muller in 1782, and he figured in the Flora Danica (tab. 883), under the name of *Conferva jugalis*, examples of a *Spirogyra* in a state of conjugation. Twenty years later the whole process was studied by a Swiss botanist, Vaucher, and described in his *Histoire des Conferves d'eaux douces* (1803),

[1] 'Ann. des Sc. Nat.,' 2me sér., tom. v.

a book which has been justly called classical, and which gives us the same pleasure in reading it that is to be found in the first account of the exploration of some entirely new country. It is worth while quoting a few sentences from Vaucher, because they illustrate very admirably the advantage of patience and persistence in this kind of study.

"I had one day," he says, "collected a considerable quantity of these plants, and, as was my practice, I was examining them rather as a matter of habit and rule than from the hope of finding anything new. I witnessed, however, a phenomenon as novel as it was unexpected. On all the segments of the cylindrical tube small swellings or papillæ, irregular in form and mostly obtuse, made their appearance. Each gradually elongated itself till it met a papilla of the other conjugating filament" (p. 43). Since this time conjugation has been observed to take place with differences in detail in other genera.

The conjugation is either effected transversely between the cells of different filaments (fig. 7 B), or longitudinally between adjacent cells of the same filament as in *Rhynchonema* and *Pleurocarpus.* In such genera as *Mesocarpus* and *Pleurocarpus* the zygospore is formed *between* the conjugating cells, while in *Zygnema, Spirogyra* and *Rhynchonema* the zygospore is formed *in* one of the conjugating cells (fig. 7 C). This may be regarded as the commencement of a differentiation which leads eventually to the type of reproduction characteristic of the *Oosporeæ.*

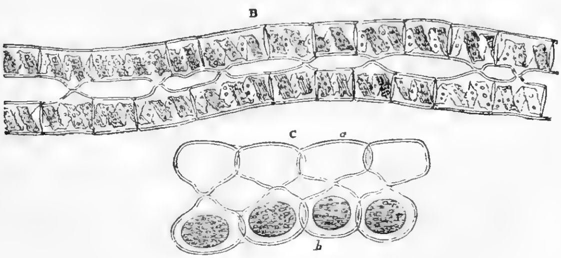


FIG. 7.—Conjugation of *Spirogyra quinina* (after Kutzing).

Amongst Fungi a similar mode of conjugation has been observed to that in *Mesocarpus.* The first instance in which it was observed was by Ehrenberg (1829), in *Sporodinia* (*Syzygites*); the other instances in which it is known are *Rhizopus* (De Bary, 1866), *Mucor fusiger* (Tulasne, 1866), *M. Mucedo* and *Phycomyces* (Van Tieghem and Le Monnier, 1872), *Chætocladium* and *Piptocephalis* (Brefeld, 1872).

In *Phycomyces*, after the partitioning of the cells to form the zygospore, a number of dichotomously branched processes are developed from the conjugating filaments.[1] Van Tieghem and Le Monnier point out that these processes are not developed simultaneously on both conjugating filaments and they trace in this a first step in sexual differentiation. It may be suggested also that the formation of the branched processes which form a kind of investment of the zygospore is a kind of anticipation of the more elaborate developments of the same kind met with amongst the *Carposporeæ*.

Sorokin has also discovered a Chytridineous plant *Zygochytrium* which produces zygospores by the union of filaments instead of zoospores.[2] This proves that there is no absolute distinction between the two processes.

Class III.—Oosporeæ.

If, as already pointed out, the two similar elements which take part in a conjugation become differentiated, we pass without difficulty from the formation of a zygospore to that of an oospore. For aught we can see to the contrary, the quantitative and qualitative factors are equally balanced in the one case, but it is evident that they are unequally so in the other. The oosphere is generally enormously larger than the antherozoid, which consequently can do little more than give the oosphere some kind of impulse. Amongst the *Zygosporeæ* either the entire protoplasmic contents of two cells of equal size take part in the conjugation, or at any rate fractions of their contents of equal value do so. It is part of the essential difference of the *Oosporeæ* that while the oosphere represents the entire contents (or in *Fucaceæ* a very large fragment) of a single cell—the oogonium, the antherozoid is only a very minute fragment of the contents of the unicellular antheridium.

Volvocineæ.—If we compare the whole series of forms usually included in this group (but which is here restricted to *Eudorina* and *Volvox*) it appears to offer a complete transition from the zygospore to the oospore. Sachs preserves a complete silence with regard to these genera, yet both are furnished with distinct antherozoids discharged from an antheridial cell.

According to Carter in *Eudorina*, the contents of the four cells adjacent to one pole of the colony undergo conversion into antherozoids, make their escape from the parent cell, and "freely come into contact with the capsules of the twenty-

[1] See 'Quart. Journ. Mic. Sci.,' 1874, pp. 63, 65.

[2] 'Quart. Journ. Mic. Sci.,' 1874, p. 298.

eight remaining or female cells (oogonia)...... to the capsules of which they apply themselves most vigorously and pertinaceously, flattening, elongating and changing themselves into various forms as they glide over their surfaces, until they find a point of ingress, when they appear to slip in, and, coming in contact with the female cell, to sink into her substance as by amalgamation."[1]

In *Volvox* antheridia and oogonia are, as in *Eudorina*, found in the same colony, which is then monœcious, or they are found exclusively in different colonies, which are therefore diœcious. The sexual cells exhibit a further degree of specialization, inasmuch as only a small proportion of the cells of a colony are developed into them. The oospheres are conspicuous by their large size, and are surrounded by a gelatinous cell-wall (oogonium). This is penetrated by the antherozoids when they escape from the antheridia (fig. 8).

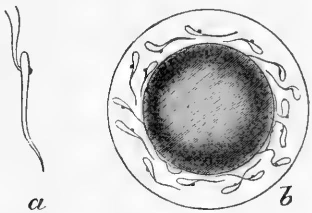


FIG. 8.—Fertilization of *Volvox*. *a*, antherozoid × 800; *b*, oogonium with antherozoids penetrating the gelatinous cell-wall × 400 (after Cohn).

SPHÆROPLEA.—If we are compelled to divorce *Eudorina* and *Volvox* from the *Pandorineæ* we are equally obliged to separate on the same grounds *Sphæroplea* from its confervaceous allies. The contents of the cells of this filamentous alga, instead of forming microzoospores, develope into oospheres and antherozoids. These are formed in different filaments, and the antherozoids being set free find their way through apertures in the walls of the oogonial cells and fertilize the oospheres.

FUCACEÆ.—As early as 1711, what we now know to be the organs of reproduction of *Fucus* were discovered by Réaumur. He observed the orange-red exudation from the openings of the conceptacles which Decaisne and Thuret (1845) showed to consist of a mass of antheridia containing antherozoids. Linnæus with tolerable accuracy described as the "feminei flores" of *Fucus* the club-shaped ends of the branches of the frond or vesiculæ, as he termed them, "adspersæ punctis perforatis semine fœtis." The male

[1] 'Ann. Nat. Hist.,' 3rd ser., ii, 1858, pp. 239, 240.

organs he identified with the hairs which line the bladders found on the fronds, but which, as Mirbel pointed out are nothing more than the *débris* of cellular tissue.

Fucus will always have a special interest in the history of these researches. It was the first alga in which the actual phenomenon of the fertilization of the oosphere, by the incorporation with it of the antherozoids, was ever witnessed. Thuret's observations on the subject were communicated to the *Académie des Sciences* in 1853. The peculiarity of the *Fucaceæ* is that both oospheres and antherozoids are set free, which is to a certain extent a return to the form of conjugation met with in *Pandorina*. The contents of the oogonium form from one to eight oospheres, which are naked masses of protoplasm destitute of motile organs. The antherozoids collect about them in such numbers as to impart to them a movement of rotation (fig. 9).

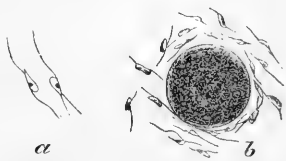


Fig. 9.—Fertilization of *Fucus*. *a*, antherozoids × 330; *b*, oosphere surrounded by antherozoids × 160 (after Thuret).

In a memoir on *Volvox* which Cohn has lately privately published as a Festschrift in honour of Prof. Göppert, he has remarked that the agreement of all the sexual relations of *Volvox* and *Eudorina* with *Sphæroplea* on the one hand, and with *Fucus* on the other, is so clear that the distribution of these algæ in two different classes must appear unnatural, and the position of all the genera named amongst the *Oosporeæ* cannot be doubted.

It will, no doubt, seem a grave objection to a classification that it requires the breaking up of a group apparently so natural as *Volvocineæ* as generally limited. The progressive morphological differentiation of the members of that group cannot fail to be apparent and to suggest their close genetic connection.

But it must now be clear that Sachs's classes have no strict genetic signification, and only mark and measure grades of development. We must still, therefore, attempt to arrange our groups in genetic linear series independently of it. These will be vertical, and will be intersected by the horizontal boundaries of Sachs's classes.

Phæosporeæ.—Sachs suggests as a provisional arrangement placing near the *Fucaceæ* the Algæ resembling them in habit, such as *Macrocystis, Laminaria, Sargassum*, &c.; of these the zoospores and antherozoids are known, but the female organs have not been discovered.

Cœloblastæ.—This group includes algæ and fungi in which the protoplasm is continuous throughout the vegetative organs of the plants, and is not divided into cells. Approximately it may be said to include the *Siphophyceæ* on the one end, and Sorokin's *Siphomycetes* (excluding the *Mucorini*, and possibly the *Chytridineæ*) on the other.

Amongst the *Siphophyceæ* we know little of the reproduction of any genus except *Vaucheria*.

The antheridia and oogonia of this genus were discovered, and their functions correctly apprehended, by Vaucher (1803)[1]. But Pringsheim first put their meaning entirely beyond doubt in 1855 by observing the actual process of fertilization (fig. 10).[2] In *Bryopsis* Pringsheim[3] believes he

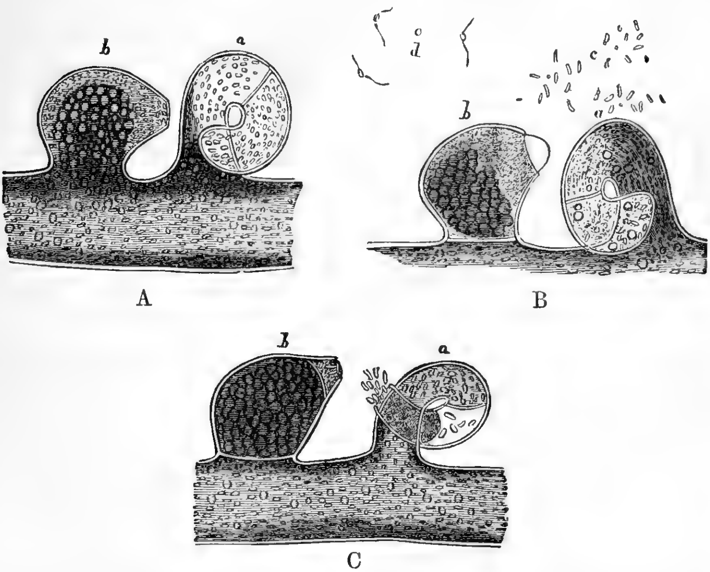


Fig. 10.—Fertilization of *Vaucheria sessilis*. A, antheridium (*a*) and oogonium (*b*) before fertilization; B, antheridium (*a*) emitting antherozoids (*c*), the cilia of which are visible (*d*) when they come to rest; C, oogonium (*b*) containing fertilized oosphere (oospore) surrounded with a cell-wall (after Pringsheim).

1 'Hist. des Conf. d'eaux douces,' p. 17.
2 'Berlin. Monatsb.,' 1855, pp. 133-165.
3 Ibid., 1871, pp. 240-255.

has found the antherozoids, but the female organs have not as yet been seen.

SAPROLEGNIEÆ.—In these plants the antheridia effect the fertilization of the oogonia by a species of conjugation. If we may contrast *Saprolegnia* with *Vaucheria* amongst *Oosporeæ*, we have a parallel contrast ready to our hand amongst *Zygosporeæ* in *Zygochytrium* and *Tetrachytrium* already alluded to. And there is the same relation between fertilization by means of a so-called pollinodium and the conjugation of filamentous processes that there is between fertilization by means of antherozoids and the conjugation of zoospores.

Braun (1851) first noticed [1] the "pollinodia" (antheridia) of *Saprolegnia*, and compared them to the antheridia of *Vaucheria*. The oogonia were described by Schleiden, who simply regarded them as asexual "spherical sporangia" [2] But Pringsheim [3] in 1857 first ascertained, with any certainty, the real sexuality of the *Saprolegnieæ*. He made out the kind of conjugation which takes place between the antheridia and the oogonia in the monœcious species, and by which, instead of by the access of motile antherozoids, the oospheres are fertilized. Pringsheim thought that, notwithstanding the conjugation, antherozoids were formed, and that in the diœcious forms, where no conjugation was possible, these antherozoids were really motile. Max Cornu (1872)[4] believes that in the forms in which conjugation is the rule motile antherozoids are not formed in the antheridium, but that this empties itself by an influx of its protoplasmic contents into the oogonium. The motile antherozoids which Pringsheim had described in the cases where conjugation did not occur, Max Cornu believes really to belong to a Chytridineous endophyte. He thinks that the antherozoids in the diœcious species closely resemble the zoospores in appearance, and have been overlooked in consequence. In *Monoblepharis* the spermatozoids are half the size of the zoospores, but of the same form; they creep with amœboid movements over the wall of the oogonium, and fertilize the oosphere by blending with it.

The latest contribution to the history of this group is that of Pringsheim in the ninth volume of his 'Jahrbucher.' He has modified his views, and proposes a very remarkable explanation of the sexual phenomena. Fertilization is always effected by antheridia; when these are absent the oogonia develop without fertilization, and are therefore partheno-

[1] See 'Rejuvenescence in Nature' (Ray. Soc.), p. 298.
[2] 'Principles of Scientific Bot.,' p. 100.
[3] 'Jahrbucher,' Pringsheim, pp. 289-305.
[4] Max Cornu, 'Ann. des Sc. Nat.,' 5e sér., tom. xv.

genetic; the spores in this case only differ from those which have been fertilized in germinating more rapidly.

ANCYLISTEÆ.—This is a new group of aquatic parasites described by Pfitzer. *See* 'Q. J. M. S.,' 1874, p. 296.

PERONOSPOREÆ.—This group of which the white rust of cabbages and other cultivated *Cruciferæ* (*Cystopus candidus*) and the potato-disease (*Peronospora infestans*) are well-known representatives, was thoroughly investigated by De Bary[1] in 1863. The phenomena of fertilization closely resemble those which take place in the *Saprolegniaceæ*. From the oospore of *Cystopus* antherozoids are produced which give rise to the sexual plant.

ŒDOGONIEÆ are a group of filamentous algæ which in many respects are typical *Oosporeæ*. The oosphere is fertilised as in *Vaucheria* by antherozoids. Zoospores, oospheres, and antherozoids are formed from the cells of the filament, an arrangement which is clearly not far removed from that which obtains in *Confervaceæ* the microzoospores of which are repre-

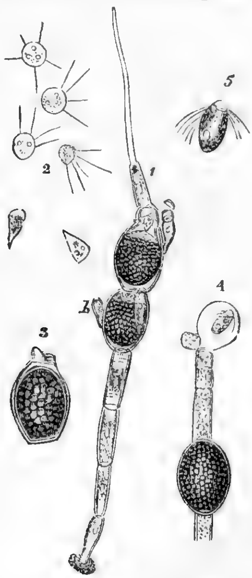


FIG. 11.—Fertilization of *Œdogonium ciliatum*. (1) Filament with two oogonia, the lower with two "dwarf males" attached, the upper with oosphere in process of fertilization by an antherozoid set free from its accompanying "dwarf male;" (2) antherozoids; (3) oogonium containing oospore; (4) filament discharging zoospore (5); (after Pringsheim.)

sented here by non-motile oospheres and antherozoids. In

1 'Ann. des Sc. Nat.,' 4e sér., tom. xx.

some species a diœcious condition exists, which reaches back to the formation of the zoospores. Some of these, instead of producing the normal plant, produce a form of a very modified character ('dwarf-males'), which attach themselves to the filaments containing oospheres, and merely serves the purpose of developing antherozoids (fig. 11). The oospore produces a succession of asexual generations. The zoospores germinate and form a filament which eventually becomes septate. Sometimes, however, while still in the unicellular condition, it discharges its contents as a zoospore by a terminal opening in a manner which suggests a comparison with *Vaucheria*. That, however, is more probably related to *Saprolegnieæ* than a reduced form of *Œdogonium*.

Alternation of generations.—The comparison of the different groups of Thallophytes requires that the relationship of the sexual and asexual generations of an organism should be taken into account. In *Nostoc* the asexual generations succeed one another uniformly; in *Spirogyra* there is equal uniformity in the succesion of generations which are sexual. But generally the two kinds are intermixed in varying proportions. In the simplest alternation a sexual and an asexual generation follow each other with perfect regularity. In others the sexual generations are intercalated at more or less remote intervals in a series the other terms of which are asexual. This is what happens in *Œdogonium*. It may easily happen that if the sexual generation makes its appearance at very distant periods it may for a long time remain unobserved. This may be the reason that it has not yet been detected in any of the *Siphophyceæ*, except *Vaucheria*.

An important feature in the life-history of any organism consists in the similarity or dissimilarity of the two kinds of generations which arise from sexual and asexual reproduction. In *Vaucheria*, for example, there is no difference between the character of the sexual and asexual plants. But such a case as a moss is a conspicuous example of the loss of all vegetative characters by the asexual generation which is reduced to a mere mass of spores. These, collectively, are due to a sexual process of which each, therefore, is only a partial product. The sporocarp of mosses represents a type of alternation of generations where an asexual one is so reduced as to have lost all individualization, and has become merely a means of extending as widely as possible the effects of the sexual act in the other generation. Good examples of this arrangement are afforded by *Cystopus*, where the oospore developes from its contents a number of zoospores; *Sphæroplea* does the same; in *Œdogonium* the oospore produces four zoospores.

In other groups this is also the case in a less marked degree. In *Mucor* the zygospore develops a filament, which, without branching, terminates in a sporangium filled with spores; here the vegetative development (represented by the filament) is not entirely suppressed. Amongst *Pandorineæ* we get an interesting condition in *Pandorina*, where the zygozoospore sets free a single zoospore, or rarely two or three, after the resting phase. According to Cohn,[1] Cienkowski, in 1856, found that the oospore of *Volvox* finally produces eight zoospores.

The anomalous sexual processes of *Myxomycetes* give rise to a many-spored fruit, which Sachs[2] suggests may be considered comparable with the sporocarp of mosses. In the organisms which belong to the next class the part played by the sporocarp, which amongst the *Oosporeæ* is only indicated in such instances as those above mentioned, rises into great prominence.

Class IV.—CARPOSPOREÆ.

The most interesting part of the taxonomic scheme which Sachs has propounded for the Thallophytes is that which relates to his fourth and highest class—the *Carposporeæ.* The following summary is in the main taken from the fourth edition of his 'Lehrbuch,' pp. 240—243.

The *Carposporeæ* agree with the *Oosporeæ,* in so far that the two sexual organs contribute in very different proportions to the formation of the sexual product. While the male only stimulates its development, the female supplies the material for the whole subsequent growth.

The female organ, or carpogonium, may consist of one or more cells. The male organ varies very considerably in the different subordinate groups. Fertilization may—as in the *Oosporeæ*—be effected by antherozoids (which may be actively motile or passively locomotive), or by a kind of conjugation, or even by a mere apposition and subsequent diffusion of the fertilizing medium.

The product of the act of fertilization is sometimes a single cell developing directly into a new individual (*Chara*). In other cases the fertilized female organ produces zoospores (*Coleochæte*), and still more usually a multicellular mass is produced in which spores are finally developed. This involves

[1] 'Festschrift,' p. 22.
[2] 'Lehrbuch,' 4th ed., p. 267.

an alternation of generations of the type of that met with in the sporocarp of *Muscineæ*. And we may have every grade of development, from the simplest case, in which the sporocarp appears as a mere appendage of the parent plant, of inconsiderable dimensions, to the most extreme condition in the other direction, in which the sporocarp is capable of independent growth, and therefore represents a second generation which is entirely distinct.

The sporocarp also differs essentially from the oospore, in the fact that cells contribute to its formation which have not been *directly* influenced by fertilisation, and that in consequence the part of the fruit which produces the spores is surrounded by what—for want of a more convenient term—we may call the *pericarp*, in which no spores are developed, and which serves as a mere protective investment, or is subsequently draw upon for purposes of nutrition.

In *Phycomyces*, which belong to the *Zygosporeæ*, it is noteworthy that there is a kind of anticipation of the development of a protective investment to the zygospore.

Coleochæteæ.—In *Coleochæte* the carpogonium (hitherto considered an oogonium) consists of a single cell tapering into a long slender canal open at the apex (fig. 12, *a*). Fertilization is effected by motile antherozoids (fig. 12, *m*), as the result of which the protoplasm contained in the basal portion surrounds itself with a firm cell-wall. Except in the presence of the long canal, there is nothing here which differs essentially from the mode of formation of the oospore in *Vaucheria* and *Œdogonium*. The essential difference consists in the fact that the apparent oospore grows after fertilization very considerably, and the cells adjacent to the female organs are stimulated into growth, and surround the fertilised female cell with a pericarp (Fig. 12, *b*). A sporocarp is thus formed, the central cell of which develops a mass of tissue, the whole of the cells of which produce zoospores, each of which is capable of giving rise to a plant similar to the original parent. Here we have the essential features of the oospore combined with the essential features of the sporocarp. The zoospores developed from the central cell must be regarded as members of a second generation, homologous with the spores of a moss.[1]

Florideæ.—In *Nemalion* the carpogonium consists of a single cell, which is thick below and elongated above into a

[1] Braun (1851) regarded the formation of the "pericarp" in *Coleochæte* as a species of conjugation analogous to what takes place in *Saprolegnieæ*; 'Rejuv.' (Ray Soc., p. 298). Pringsheim (1860) made out the true nature of its development ('Jahrb.,' vol. ii).

closed hair-like body—the Trichogyne. The antherozoids attach themselves to this. A further development of the basal

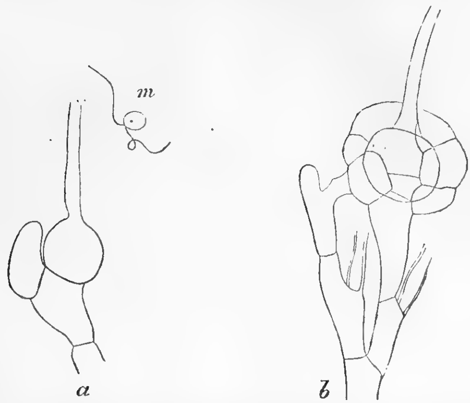


Fig. 12.—Diagrammatic representation of the development of the sporocarp in *Coleochæte; a*, carpogonium with antherozoid (*m*); *b*, fertilized carpogonium invested with its pericarp (after Pringsheim).

cell of the carpogonium results; it increases in circumference, divides into numerous cells, which grow out into closely crowded shoots; at the end of each a spore developes. The aggregate of the spores, with their short pedicles, constitute the sporocarp, which is in *Nemalion* destitute of a pericarp.

Nemalion is the simplest type of the *Florideæ*. In others (*Ceramieæ*) the carpogonium, even before fertilization, consists of numerous cells (fig. 13, *b*), a lateral row of which—the Trichophore—bears the trichogyne. Fertilization takes place as in *Nemalion*, but neither trichogyne nor trichophore take any part in the subsequent development. The sporocarp results from the growth and division of other cells of the carpogonium. The pericarp is produced by a process of budding from cells beneath the carpogonium.[1]

In the genus *Dudresnaya* the process of fertilization becomes very complicated, and, in fact, involves a double process, of which the first stage consists in the application of antherozoids to a trichogyne, and the second in the development, from below the trichophore, of a "conducting filament," which conveys the fertilizing influence to the terminal cells of a number of small branches, with which it successively

[1] The trichophore and trichogyne were discovered (1861) by Nageli; the sexual meaning of these structures was made out by Bornet and Thuret (1866); see 'Ann. d. Sc. Nat.,' 1867, tom. vii, p. 137. The antheridia of the *Florideæ* were discovered by Ellis in 1757.

conjugates. At each point of conjugation a sporocarp is developed.

Amongst the *Ceramieæ* it may be observed that there is something comparable to this double process.

The fertilizing influence which is conveyed by antherozoids to the trichogyne have afterwards to be communicated by a process of diffusion from the trichophore to the cell from which the spores are developed.

CHARACEÆ.—Certainly, however, the most ingenious interpretation which Sachs has proposed is that by which *Chara* is assigned a position amongst the *Carposporeæ*. Translating his words (' Lehrbuch,' 4th ed., p. 242) :—" The sporocarp of *Chara*, which has hitherto stood in an entirely isolated position, becomes intelligible when we compare it on the one side with *Coleochæteæ*, on the other with the *Florideæ*. The carpo-

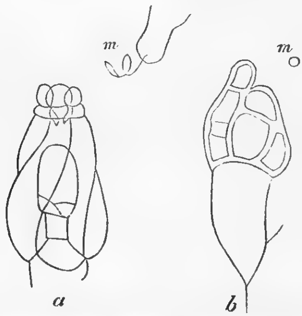


FIG. 13.—Diagrammatic representation of the carpogonium in *Chara* and *Lejolisia*. (*a*) *Chara* (the pericarp developed before fertilization), the basal cells (trichophore) of the carpogonium are shown; (*m*) motile antherozoid (after Sachs); (*b*) *Lejolisia* (pericarp not developed); the trichophore and undeveloped trichogyne shown on left-hand side; (*m*) passively motile antherozoids (after Bornet).

gonium consists of a large cell supported by several smaller basal ones, which take no part in the growth resulting from fertilization. They play, therefore, the part of a trichophore although there is no trichogyne, and fertilization is effected by motile antherozoids which blend directly with the carpogonium." A one-spored sporocarp is the result; the pericarp is formed before fertilization.

Chara is, therefore, in its reproductive aspects a *reduced* type of *Carposporeæ*. The trichophore is rudimentary, and the carpogonium unicellular instead of multicellular. These simplifications of the arrangements, which in other allied *Carposporeæ* precede fertilization, are balanced by the previous instead of subsequent development of the pericarp.

The peculiar mode of development of the "cortex" of the stem of *Chara* is also a matter in which a comparison may be made with some of the *Florideæ*, such as *Ceramium*.[1]

Turning now to the series of fungoid forms we find a considerable number of which the sexual reproduction in its main points agrees with that of the *Florideæ*.

ASCOMYCETES.—*Erysipheæ*.—This group, although not the earliest to be investigated, supplies us with the least complicated case of a sporocarp. In *Podosphæra*, in which its development was described by De Bary in 1870,[2] the carpogonium and antheridium are both unicellular. After fertilization the carpogonium divides into two cells, the upper of which produces spores in its interior, and so may be regarded as an ascus; the pericarp is formed of short filaments which branch out below its pedicle.

Baranetski[3] has described under the name of *Gymnoascus* a fungus found on horse and sheep dung, which is probably a reduced rather than a simpler form of such a type as *Podosphæra*. The carpogonium and antheridium closely resemble one another, but after fertilization the carpogonium divides into a number of cells, which grow out into filaments producing asci at their extremities. There is only an indication of the formation of a pericarp.

Amongst the *Erysipheæ* must also be placed *Aspergillus*, the sporocarp of which has been described as a distinct genus under the name of *Eurotium*.

Discomycetes.—The sexual reproduction of the larger fungi was first observed by De Bary amongst the members of this

[1] The taxonomic migrations of *Chara* have been most remarkable. Linnæus originally placed it in his group of *Algæ*, the contents of which, however, were in many respects heterogeneous. In the twelfth edition of his 'Systema' he transferred it to flowering plants ("ad mentem Scheberi," as Hedwig tells us, 'Theor. Gen.,' p. 125). It has been referred to *Naiadaceæ* by Jussieu and De Candolle, and to *Hydrocharaceæ* by Brown. Richard (1815) established it as a separate order. Agardh referred it to *Confervaceæ*. Endlicher and Lindley associated it with other *Algæ* (see Lindley, 'Veg. Kingd.,' 3rd ed., p. 26). Latterly it has been rather the fashion to regard *Characeæ* as an independent or problematic intermediate group, standing between Thallophytes and Cormophytes. This was the view taken by Schleiden and by Sachs up to the fourth edition of his 'Lehrbuch.'

The contemporaries of Linnæus were acquainted with the reproductive structures of *Chara*. Correa de Serra (1796) thought that the pollen consisted of mucus, and was conveyed to the germen by a kind of circulation. Bischoff (1828) discovered the antherozoids, and Thuret (1840) observed the cilia upon them, this being also their first discovery on the antherozoids of any plant.

[2] 'Beitr. z. Morph. u. Physiol. d. Pilze,' dritte Reihe.

[3] 'Bot. Zeit.,' 1872.

group. His observations in 1863 (on *Peziza confluens*) were further confirmed and extended by himself and Tulasne in 1866, and more recently by Janczewski in *Ascobolus* (fig. 14).[1] The carpogonium is no longer unicellular, but consists of a row of numerous cells, which is fertilized by the ramified antheridium. As a result of this process numerous filaments branch out from the middle cell of the carpogonium, which in their

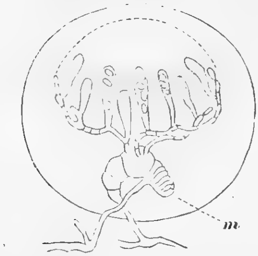


FIG. 14.—Diagrammatic representation of the development of the sporocarp in *Ascobolus*. The ramified antheridium is shown applied to the end of the multicellular carpogonium, from the middle cell of which the asciferous filaments are developed. The external outline indicates the boundary of the subsequently formed "pericarp." (After Janczewski.)

turn develop the asci. The pericarp, which forms a solid pseudo-parenchymatous investment, is formed of consolidated filamentous branches of the mycelium below the carpogonium. The mycelium itself, from which these comparatively large sporocarps are developed, is relatively inconspicuous. The sporocarp constitutes, in point of fact, a second and distinctly marked independent generation.

Tuberaceæ.—This group is characterized by the sporocarp not being aerial, as in the former groups, but subterranean. The well-known *Penicillium glaucum*, of which the conidiferous form is so common, has been found by the beautiful investigations of Brefeld,[2] to produce a sporocarp which is analogous to *Tuber* in its structure. Such a relationship is probably the very last that could have been, *à priori*, suggested for it.

Pyrenomycetes.—In this group the asci are contained in a bottle-shaped perithecium. The perithecia may either occur singly as in *Sphæria*, or aggregated as in *Claviceps*, in a so-called stroma. In the former case the researches of Woronin prove that each perithecium is the result of a process of fertilization.[3] In the latter case it is as yet doubtful what

[1] 'Bot. Zeit.,' 1871.

[2] 'Bot. Untersuch. u. Schimmelpilze,' heft ii, 1874.

[3] De Bary and Woronin, 'Beitr. z. Morph. u. Phys. der Pilze,' Erst. Bd., dritte Reihe, 1870.

happens, but it seems probable that *one* act of fertilization may give rise to *numerous* perithecia, and the sporocarp must therefore be regarded as compound instead of simple.

Lichens must now be placed, as indicated above, amongst the *Ascomycetes.* Their fructification may be referred partly to the type of *Discomycetes,* such as we find in *Peziza,* partly to that of the *Pyrenomycetes,* such as we find it in *Sphæria.* But in no case at present has the sexual act which doubtless underlies the development of their apo- and peri-thecia been detected. This would, indeed, if observed, conclusively clinch the case in favour of the Schwendenerian theory of Lichens.

Æcidiomycetes.—No observations of any sexual organs have been made in this group.

Basidiomycetes.—In the last edition of his 'Lehrbuch,' Sachs remarks that though no sexual process had been detected in the case of any form belonging to these fungi, analogy would lead to the supposition that the mycelium developed sexual organs, and that the spore-bearing body must be regarded as a sporocarp. Amongst the *Erysipheæ* and even the *Discomycetes* the degree of differentiation exhibited by the constituent tissues of the pseudo-parenchymatous mass of which the sporocarp is, at first at any rate, principally composed, is not very striking. But amongst the *Basidiomycetes* the gradual evolution of the final spore-bearing structures is in such genera as *Phallus* and *Crucibulum* most elaborate.

Attempts which have fallen out of notice have been made by Karsten as well as by Œrsted[1] to establish the fact of a sexual process amongst the *Basidiomycetes.* The most recent observations are those of Van Tieghem[2] on *Coprinus.* Van Tieghem found by sowing the spores in a solution of horse-dung that they are diœcious. They produce a mycelium which, in the case of a male spore, developes from the ends of lateral branches tufts of minute rod-like bodies (antherozoids), which fall off and are renewed like the conidia of a *Penicillium.* The mycelium developed from the female spores produces upon its branches, only more slowly, club-shaped bodies (carpogonia), three or four times as long as broad, and terminated at the apex by a small papilla, which Van Tieghem describes as playing the part of a trichogyne, the rod-like non-motile antherozoids becoming affixed to it. The contents of one of these pass into the carpogonium, leaving the empty cell-wall attached to the papilla. Van

[1] See 'Quart. Journ. Mic. Sci.,' 1868, p. 18.

[2] 'Comptes rendus,' Feb. 8, 1875, p. 373.

Tieghem even succeeded in cross-fertilizing the carpogonia of *Coprinus ephemeroides* with the antherozoids of *C. radiatus*.

Rees,[1] working about the same time on *Coprinus stercorarius*, has observed the development of the "antherozoids," and has also seen the fertilized carpogonia, but he had not observed their unfertilized condition, or the process of fertilization.

IV.

From the preceding sketch of the present state of our knowledge, it will be seen that Sachs's classification, though in some respects it does violence to a perfectly natural arrangement, on the whole succeeds in marshalling the Thallophytes according to their morphological complexity. That being the case, it must, to a certain extent, have also a phylogenetic significance. Sachs's four classes are, in fact, as already suggested, horizons which intersect the branches of the yet imperfectly understood phylogeny. And it is probable that the groups included between these horizons are rightly placed there, but that what we have still to learn is their vertical relations to one another. So far, then, the classification is an improvement on most artificial classifications, which usually, on grounds of expediency, abandon all attempt to preserve anything of a natural, *i.e.* of a phylogenetic, arrangement. Even Linnæus, who is generally regarded as the great supporter of utilitarian taxonomy, was by no means satisfied with an artificial classification. At the commencement of his 'Fragmenta Methodi Naturalis' (1738) he declares, "Diu et ego circa methodum naturalem inveniendam laboravi, bene multa quæ adderem obtinui, perficere non potui, continuaturus dum vixero."

In the third edition of his 'Lehrbuch,' Sachs suggested that the Algæ were the original stock of the vegetable kingdom, and that the Fungi branched off from the *Siphophyceæ*, which produced the *Phycomycetes* and these in turn the other types. The agreement between these two groups of unicellular *Oosporeæ* is undoubtedly very great, and it is sufficiently explained if we suppose that the *Phycomycetes* are simply *Siphophyceæ* modified for a parasitic life. There is no reason to suppose that the agreement has more significance than this, and Sachs has therefore abandoned the *Siphophyceæ* as the starting-point of the fungoid series.

Without attempting actually to construct a phylogeny of

[1] 'Ueber den Befruchtungsvorgang bei den Basidiomyceten; Sitzungsb. d. Physik. Med. Soc. in Erlangen,' Hft. vii, 1875.

the *Thallophytes*, a few remarks may be made as to the indications which might be made use of for such a purpose.

The *Schizomycetes* would appear to afford a starting-point. Those who advocate spontaneous generation will probably seize upon this as an important admission. Nevertheless there are good grounds for believing the doctrine which may be formulated as '*omne protoplasma e protoplasmate.*' Mr. Herbert Spencer is probably right in his conjecture that conditions once existed in which the interval between the chemical combinations which obtain in the organic and the inorganic world might easily be passed, while now apparently they cannot be, or only with extreme difficulty. Under such conditions, matter doubtless existed in such states of spontaneous aggregation as fitted it to subserve the nutrition of Bacteria. Now, we know that it only does so when derived from some organic source.

The interesting observations of Professor Lankester, on *Bacterium rubescens*[1] seem to show that we may pass without much difficulty from the *Schizomycetes* to forms belonging to to *Chroococcaceæ,* and other writers have also indicated their relationship to *Oscillatorieæ.* From *Chroococcaceæ* we pass apparently through *Palmellaceæ* (*Palmella cruenta*), *Pleurococcus*, *Confervaceæ* (proper), *Œdogonieæ*, *Coleocheteæ*, *Nemalion*, *Florideæ* to *Chara.* This has been probably the course of the main line from which branches would be given off, which readily suggest themselves. The earliest plants, supposing them to have been allied to *Schizomycetes,* were therefore probably more like the Fungi than the Algæ. And the food which is now furnished to Fungi from the organic world must then have been obtained from inorganic sources. Chlorophyll we may imagine to have made its appearance when these pseudo-organic sources of nutriment ran short, and to have been seized upon by a kind of natural selection as soon as its power of promoting deoxidation in substances fitted for plant nutrition made itself manifest.

Turning now to the forms from which chlorophyll is absent (Fungi), it must be remarked that notwithstanding the remarkable morphological parallelism which, as has been shown, they present at every step to the forms in which chlorophyll is present, it is still much more easy to connect them in a series with one another than to suggest, at present, the transverse links. It is interesting, however, to note the tendency of truly algoid types to assume a parasitic and consequently fungoid life. Reinsch finds that almost every large

[1] 'Quart. Journ. Mic. Sc.,' 1873, p. 408.

red seaweed is attached by species of *Entonema*. Other red seaweeds support a parasitic form (*Choreocolax*) which is itself a Rhodosperm.[1]

Except in the case of the *Siphophyceæ* already mentioned, it is difficult to imagine any passage from, for example, *Zygnemeæ* to *Mucorini*, or *Florideæ* to *Ascomycetes*. We can see indications of a linear series from *Zygomycetes*, *Saprolegnieæ*, *Ascomycetes*, perhaps to *Basidiomycetes*. And possibly *Zygomycetes* may have been not very remotely derived from *Schizomycetes*.

If the lines of *Algæ* and *Fungi* really were as this would seem to indicate, after all, distinct, the undoubted fact of their morphological parallelism is one of the most remarkable and yet suggestive facts in the whole field of Biology.

W. T. THISELTON DYER.

[1] Reinsch, 'Contributiones ad Algologiam et Fungologiam,' 1874. See also, for other instances, 'Quart. Journ. Mic. Sc.,' 1873, p. 366, and 1874, p. 295.

PROCEEDINGS OF SOCIETIES.

Medical Microscopical Society.

Friday, December 18th, 1874.

Jabez Hogg, Esq., President, in the Chair.

Dr. Payne made a communication upon the presence of Bacteria in disease.

He remarked that organized bodies were found not only externally as in parasitic diseases of the skin, but internally as in malignant pustule, where bacteria in large quantities were seen in the blood and in the discharges, forming the materies morbi of that affection. In the class of specific fevers and in pyæmia from wounds, similar organized structures form the materies morbi also. The presence of these bacteria is best studied in pyæmia.

The majority of these cases are from injury, the disease beginning locally and spreading throughout the body—a proposition not always admitted; and hence the old theory that pus was the material carried in the blood current. This is disproved by two considerations: 1st. That the pus actually forms where the secondary deposit appears. 2nd. There is no proof of the absorption of pus.

The nature of the materies morbi and its method of transmission were then dwelt upon; with regard to the latter point, until Virchow's theory of thrombosis, two views were held; one that pus got into the veins coming from the seat of injury and of suppuration; the other that the pus began in the veins, the result of phlebitis. According to Virchow, clots were first formed in the veins; they softened and the products of their disintegration were carried into the system. This explanation not satisfying all cases—especially those of puerperal pyæmia—it was suggested that the same septic matter is conveyed by the lymphatics; and recent research would seem to show that these latter were really rather concerned in its transmission than the veins. Then followed Virchow's theory of Embolism, the complement of that of Thrombosis; but even a plug in a vessel failed to explain the general disorder of Pyæmia, and hence the attention was directed to the nature of the materies morbi itself.

With regard to the nature of this material Dr. Payne pointed out that bacteria were found in cases of pyæmia, and generally if the specific fevers were properly searched for. The examination of the blood for these did not give constant results, and the mobile granules derived from white blood-corpuscles were not to be confounded with bacteria, nor in examining solid tissues after death were the bacteria of putrefaction to be mistaken for those of disease. The former were rod-shaped, those of disease spherical, resisting the action of alcohol, ether, or caustic potash. Prof. Heiberg, of Norway, found in pyæmia from wounds clots in the veins, composed of granular amorphous material, that closer observation showed to be formed by bacteria. In the arteries going to secondary deposits and in the areolæ around them in pyæmia, similar masses of bacteria had been seen. These observations Dr. Payne had to some extent verified himself. In the kidneys the tubes had been noticed plugged by the same material; this being the way of exit of the bacteria from the body according to Heiberg. In pyæmic meningitis Dr. Payne had seen bacteria in the lymphatic spaces, not in the vessels.

The important and to some extent novel feature in Heiberg's observations was the detection of bacteria in the solid organs at the actual seat of disease. This line of investigation was specially and urgently recommended to medical observers with the microscope.

To examine the Bacteria, though visible with $\frac{1}{4}$-in. objective, 600 diameters should be employed at least, and in dealing with the solid organs a softening part should be chosen; a section made at once with a Valentine's knife, and the specimen be immersed in caustic potash and water, in which medium it is best examined, other reagents being applied in the usual way.

The President had observed in putrefying infusions first spherical Bacteria appear and then the oval, and thought that observers were apt to make too many species of these bodies.

Friday, January 5th.

ANNUAL GENERAL MEETING.

From the report of the Committee it appeared that the Society was in a flourishing condition, the number of members being 135. The number of papers read during the past year was 16, besides several minor communications, all of which were followed by brisk discussions. Above 100 specimens were exhibited during the year, and 18 were presented to the Society.

A present was also announced of a microscope for use in the *Exchange* of specimens—a system which is found to work well and offers great facilities for obtaining a large collection of good preparations. The Treasurer's Report showed a balance of £15 10s. The following officers were elected:—

President—Dr. J. F. Payne.

Vice-Presidents—Mr. Jabez Hogg; Mr. W. B. Kesteven; Mr. H. Power and Dr. U. Pritchard.

Treasurer—Mr. T. C. White.

Hon. Secretaries—Mr. C. H. Golding Bird and Mr. J. W. Groves.

Committee.

St. Bartholomew's—Mr. J. A. Ormerod.
Charing Cross—Dr. M. Bruce.
St. George's—Mr. E. C. Baber.
Guy's—Mr. F. Durham.
King's—Mr. H. S. Atkinson.
London—Mr. J. Needham.
St. Mary's—Mr. Geo. Giles.
Middlesex—Dr. S. Coupland.
St. Thomas'—Dr. W. S. Greenfield.
University College—Mr. E. A. Schäfer.
Westminster—Dr. W. H. Allchin.
General Profession—Dr. Foulerton.

The retiring President then read an address, which was followed by a vote of thanks to the various officers, and the proceedings terminated.

Dublin Microscopical Club.

January, 1875.

Polysiphonia Californica and its immediate allies.—Prof. E. Perceval Wright exhibited specimens of *Polysiphonia Californica*, Harv., with capsules and tetraspores. The former were decidedly stalked and quite unlike those of our native *Polysiphonia atrorubescens.* Harvey would seem to have regarded his *P. plumigera* as a var. of *P. Californica*, and as perhaps connecting this form with *P. bipinnata*, P. and R. Ruprecht in describing his *P. gemifera*, refers to it as being very closely related to *P. bipinnata*, P. and R., so that it is by no means impossible that all these forms may on due investigation be referred to as local forms of one species with a geographical distribution extending over the whole of the northern portions of the Indian Ocean, on the Western American coast as far south as California, and on the Eastern Asiatic coast to the Amoor district.

Embryo of Capsella.—Prof. McNab exhibited an embryo of *Capsella* at an early stage of growth, which presented the three layers of cells described by Hanstein as dermatogen, periblem, and plerum. The formation of the pileorhiza and the hypophysis was also distinctly shown.

Structure of spine of Asthenosoma varium, Grübe.—Mr. Mackintosh exhibited a section of a spine of this species. These are short, moderately slender, verticillate or longitudinally striate, in section presenting two types of structure. One form, belonging to the striated spines, has the central hollow small and surrounded by very abundant reticulated tissue, solid pieces indistinct. Second form, belonging to the verticillate spines, has the central hollow variable in diameter, sometimes entirely obliterated by network; reticulated tissue variable in quantity, solid pieces in the form of bars, dilated at the circumferance into paddle- or spade-shaped forms.

Composition of Vesuvian Lava.—Prof. Hull, F.R.S., exhibited a thin slice of Vesuvian lava of the year 1868, remarkable for the large number of well-formed crystals of leucite containing fluid-cavities, visible with comparatively low powers. Although the occurrence of such fluid-cavities is not unusual, and has been noticed by Zirkel, Rosenbusch, and others, yet, out of fifteen slices examined under the microscope from different beds of lava poured forth during the last 200 years, there were none found in which the cavities with fluid bubbles were so numerous as this of the year 1868. The cavities generally correspond to the angles of the crystal, which in section is an octagon, and in some cases a double row of cells was to be observed. The crystals were set in a paste consisting of mineral glass, plagioclase, augite and titanoferrite, intimately mixed; containing along with the leucite—sodalite, mica, and other substances. It was assumed that each bubble of fluid contained in the cavities was originally in the state of steam, which must have been present in great quantity during the solidification of the lava.

Mr. Porte remarked, some others of the meeting being disposed to concur with him, that the optical aspect of these little "bubbles" appeared rather that of air-bubbles than of fluid. Some experiments were then tried as to whether these little bubbles could be made to alter their position by inverting the preparations, but no such alteration seemed to take place.

Leaves Stained and Mounted in "Deane's Gelatine."—Mr. G. Pim showed preparations of leaves mounted as permanent specimens, which had been first bleached by nitric acid and water, equal parts, to which was added one drachm of chlorate of potash per ounce; they were then washed and stained, some in "Dichroic Ink," some in tincture of carmine, and some in a mixture of both, and then mounted in "Deane's Gelatine." These formed readily examined preparations; by "focussing down" the epidermis, veins, and median tissue, could be successively brought into view.

Aphis Vastator mounted twenty-five years ago exhibited.—Mr. Robinson showed preparations of foregoing, mounted so long ago as twenty-five years by Topping, and in as good condition as ever.

Colorado Beetle exhibited.—Mr. Kirby showed a specimen of the much-talked-of and dreaded Potato-pest, the Colorado beetle; he exhibited a leg of same under the microscope.

New Species of Coscinodiscus, C. Moseleyi, O'Meara, *exhibited.*—Rev. E. O'Meara presented a Coscinodiscus from material collected at Kerguelens Land, by Mr. Moseley, of H.M.S. "Challenger," which he named as above. It stands in close relation to the group of which *C. omphalis* may be regarded as the type; it is very large, being in diameter 0·02, and so much arched that, when the central umbilicus is in focus, the margin is unseen. The central rosette consists of about eight large areoles of unequal size, generally flattened. The areoles are small, irregularly quadrate, area radiate, the radii united in fascicles of about ten each, the areoles of equal size throughout. Viewed under a low power the valve is iridescent and looks like *Actinocyclus Ralfsii*, from which, however, in all other respects it is obviously distinct. Mr. O'Meara was about to prepare special descriptions and figures of this and other forms met with in this material.

Section of Coal with embedded Crystals.—Mr. Porte exhibited a section of Derbyshire Coal, which he had prepared in order to show its woody structure; he found unexpectedly that it was traversed obliquely across the woody fibres by a seam of some crystalline substance (nearly a sixteenth of an inch in width), which polarized beautifully and not unlike Salacine. Mr. Porte suggested that its formation was owing to a fissure in the coal into which the crystalline matter in a state of solution percolated, and that it was afterwards subjected to a temperature sufficiently high to fuse the crystals, their structure appearing to him to indicate crystallization from a state of fusion rather than from solution, but what the substance is he would not at present venture to say.

Nuclei in two Heliozoan Rhizopoda.—Mr. Archer drew attention to fugitive preparations of two Heliozoan Rhizopods treated with Beale's carmine solution, in order to show the "nucleus" (Hertwig) or "central-capsule" (Auct.), but without which treatment these structures could not be recognised. These were *Heterophrys Fockii* and *Raphidiophrys viridis*, Archer. The former was an exceedingly fine example, composed of eight conjoined individuals; the junction when living being by a narrow isthmus or band of sarcode, as well as by numerous ordinary pseudopodia, these mostly projecting around in every direction, had been unusually strong and long. The nuclei—in the living state invisible—now came out as minute sharply bounded globular bodies, strongly imbibing the dye. The examples of the other rhizopod, *Raphidiophrys viridis*, were remarkable for being, on the other hand, nearly all composed of but a single "individual," densely charged, as usual, with abundant and rather large chlorophyll granules. It is remarkable that here, in each example, several subglobular bodies, not before evident, became highly dyed by the carmine—quere, all nuclei—and betokening the ultimate subdivision of the aggregate body-mass into so many subdivisions of a future colony, that is, an ordinary compound example? It is a pity the comparative rarity with which these heliozoan forms turn up render the opportunities for experiment so isolated and postponed.

Feb. 18th, 1875.

Limnoria terebrans attacking Telegraph Cable, exhibited.—Mr. A. Andrews showed an example of *Limnoria terebrans* taken from the submarine cable between Ireland and Holyhead. Mr. Sanger mentioned that the present was the first instance in Europe of this borer attacking a telegraph cable. It was discovered that a fault had occurred in the present instance somewhere not far from Holyhead, and on taking up the cable it was with difficulty that the injury was traced at last to its real perpetrator, which, however small as is a single example, caused eventually a loss to the Company of some £10,000. The application of creosote seemed to be the only preventive of the depredations of this little crustacean, whose newly evinced taste for gutta percha seemed hardly less than its older and well-known one for timber.

Solenonema æquale, Diesing, *exhibited.*—Dr. Macalister exhibited a specimen of *Solenonema æquale* found by him in the cellular tissue behind the bladder in the Anteater, *Myomecophaga jubata.* The same species was described from the same host by Diesing, and published by him in his 'Revision der Nematoden' (1861), p. 709.

Gelatinous algæ, shown.—Dr. Moore exhibited a sample of gelatinous stuff taken from the ground in a wet moor in Connemara, containing a variety of algal forms interspersed with hyphæ, probably of lichenous origin, well showing how a variety of distinct entities sometimes go to make up a stratum at first sight seemingly *sui generis;* amongst these were chlorophyllaceous and phycochromaceous forms, such as *Mesotænium violascens,* de Bary, on the one hand, and forms of Aphanotheee, Näg., and Glœocapsa, others (= Coccochloris, Auct.), in part, on the other.

Vaginicola-form, unidentified, shown.—Dr. J. Barker showed a form of Vaginicola, which appeared to be probably new, the two animalcules being seated in a lorica of very globose figure below and narrowed upwards, but the necklike portion was still very broad,—thus, it was shaped like a hyacinth-glass, with a comparatively short neck.

Section of Baryta mineral, shown.—Dr. Tichborne exhibited a section of baryta mineral, which consisted chiefly of carbonate of barium, with a little silica, &c. It bore some superficial resemblance under the microscope to a section of wood. The crystals radiated generally from the centre, but were crossed at intervals by annular markings, which were opaque and were found on analysis to consist of carbonaceous matter; the section was shown as a polariscopic object for the purpose of rendering the rings evident.

Structure of Spine of Parasalenia gratiosa, A. Agass.—Mr. Mackintosh presented a transverse section of the spine of *Parasalenia gratiosa,* A. Agass. In this the central portion is occupied by a reticulation of roundish cells; from this branch out a number of solid "spokes" which dilate at the circumference into broad segments, which are very finely serrated on the outer margin and give rise to the longitudinal striation of the spine. In structure it approaches somewhat to *Arbacia punctulata*, Gray, with a section of a spine of which it was compared.

Diatoms from Silt on Timber from Demerara.—Rev. Eugene O'Meara submitted to inspection a slide of diatoms for which he was indebted to the kindness of Rev. George Davidson, of Logie-Coldstone, near Aberdeen. The material from which it was prepared had been gathered by Mr. Rattray from some balks of timber known as "greenheart" and brought from Demerara. This timber, when cut in the interior, is sent down the river and allowed to remain there until an opportunity of shipment is afforded, meanwhile it is covered by the silt brought down the river. The forms found on this slide were many of them undescribed and very beautiful. Mr. O'Meara hoped that the finders would take means to have these forms described in order that the interesting discovery should not be lost.

Endosperm of Ricinus.—Dr. McNab exhibited a section of the endosperm of *Ricinus communis*, the castor-oil seed, with a $\frac{1}{12}$th object-glass by Gundlach. The section was placed in a mixture of equal parts of pure glycerine and water, which brought into view the numerous crystalloids which occur in the cell along with the oil. These are mostly octohedra, the faces, angles, and edges being, however, not very sharply defined.

Spicules of Wrightella coccinea, Gray.—Mr. W. M. A. Wright exhibited a series of spicules from the coral called by Dr. J. E. Gray, in his 'Catalogue of the Stony Corals in the Collection of the British Museum' (1870), *Wrightella coccinea.* These specimens, given to him by Prof. E. Perceval Wright, had, like those in the British Museum, been collected by that gentleman in the Seychelles. The spicules were of two kinds—one bacilliform with a few warty excrescences, the other like those called "head-shaped" by Verril. Dr. Wright had informed him that he did not think there was any specific difference between *Wrightella coccinea* and *W. chrysanthos*, and that it was quite possible that both species were referable rather to Ellisella.

Crystal-bearing Cells in Pandanus amaryllidifolius.—Dr. E. Perceval Wright drew attention to sections of stem of *Pandanus amaryllidifolius*, which exhibited the strings of crystal-bearing cells on the outside of the fibro-vascular bundles as described by Professor Thiselton Dyer; but in many instances Dr. Wright thought the sections showed these same rows of crystal-bearing cells occurring in the region between the epidermis and the central fibro-vascular bundle region.

Spores of Elaters of Trichia turbinata, shown.—Mr. Greenwood Pim exhibited the spores, accompanied by the beautiful triply-spiral elaters, of *Trichia turbinata.*

Exhibition of some of Prof. Bornet's original Lichen-gonidia preparations.—Mr. W. Archer showed some preparations kindly forwarded by Prof. Thiselton Dyer, put up by Dr. Bornet in illustration of his Memoir on the "Lichen-gonidia question." These were all very beautiful and striking—perhaps the most so that of the minute lichen with its hyphæ investing a form of Phyllactidium or probably Coleochæte, its apothecia scattered over the surface and seemingly making that alga do duty as "gonidia."

The apothecia with asci and their separate spores were readily seen. In his memoir Dr. Bornet mentions that no evidence was present of fructification in the alga, also that no bristles showed themselves indicative of the genus Coleochæte. These latter certainly seemed to be absent, but the fronds in the present examples showed certain thickenings dotted here and there, these appearing as if made up of a more dense tissue than the remaining portions of the very pretty frond, and these sori-like agglomerations being imbedded therein. Now, these had much of the appearance, one might readily suppose, of the beginnings of the female fructification, or rather resembled the cortical stratum of cells surrounding the female cell in *Colochæte scutata*, Bréb.; quere, then were these really incipient or arrested fructification? Although there was no evidence of chætæ or bristles, but these even in some European Coleochæteæ are not always present. Kützing describes no bristles for his phyllactidium, but nevertheless it seems generally regarded that his plant must represent a Coleochæte, Bréb. The habitat on the leaves of living trees in the tropics is singular; no Coleochæte appears to be known in Europe otherwise than submerged in water; such, on the Schwendenerian view, could never play the part of "gonidia-formers."

MEMOIRS.

On Myelitis, *being an* Experimental Inquiry *into the* Pathological Appearances *of the same.* By D. J. Hamilton, Author of the "Astley Cooper Prize Essay" on "Diseases and Injuries of the Spinal Cord." (With Plate XVI.)[1]

So much doubt still exists as to what are the characteristic pathological appearances of inflammation of the spinal cord, and so many diverse conditions have been described as such which no doubt owed their origin to entirely different pathological processes, that, as yet, we may be said to possess no literature which can form a guide in telling us whether this or that condition is an inflammatory affection, and which clearly differentiates this from the many other pathological changes to which the spinal cord and all nervous tissues are liable.

Softening, hardening, disintegration, and numerous other states of the organ have all been proposed as characteristic of its inflammation without any attempt to describe the stages or means by which these so-called pathological lesions have been brought about. One great source of fallacy in regard to the proper understanding of this matter is the inability to distinguish between the lesions known as "secondary degenerations" produced by failure of the *trophic* or *nutritive nervous action* exerted by the nerve-cells on the fibres to which they are attached, and those which are localised to a certain spot, and which are probably dependent on some distinct *origo mali* in their neighbourhood. For, granted that we have degeneration of a few nerve-cells in portions of the cerebrum, it is almost a certainty that if the subject of the lesion has lived long enough, the fibres in the spinal cord in communication with these will have also degenerated, will have undergone fatty disintegration, and will be softened. How easy, then, in such a case to mistake this for a local affection, instead of referring it to its true source, namely, the primary degeneration of the cerebral nerve-cells.

[1] Read at the Medical Microscopical Society, May 21st, 1875.

Other grave sources of error are undoubtedly *post-mortem* change and the method of preparing specimens for examination. I have very often found that all manner of lesions, softenings, areas of disintegration, varicose nerve-sheaths, &c., can be artificially produced by merely placing the specimens, while they are being hardened, in an atmosphere with a temperature such as is generally maintained in our ordinary households. One of the most important conditions for drawing correct conclusions is, especially for the first week, to keep the temperature of the parts to be hardened as low as possible —at 32° F. or very slightly above it. In this way we can prevent decomposition until the reagent used in hardening has had time to penetrate into the interior of the tissue, and partially to harden it by a process very similar to what is pursued in tanning.

If, again, we place the part in too strong a solution of chromic acid, the outer limits become so rapidly hardened as effectually to prevent the ingress of reagents to the interior, which accordingly undergoes decomposition. My own method of preparation, described further on, is calculated to do away with these deficiencies, and to present the specimens to the eye as nearly identical with the appearances during life as possible.

The experiments which are about to be described were undertaken with the object of first producing a lesion which we know to be an *inflammatory* one, and then making the most careful examination, all preconceived ideas on the subject of inflammation generally being purposely laid aside. The appearances were merely carefully noted and abundantly verified by repetition of the experiments and observations. Everything is purposely omitted which could mislead, for want of confirmation, and only those facts which by constant repetition were found to be invariable are here stated. I have also been favoured with the valuable confirmatory evidence of Professor Stricker, in whose laboratory for experimental pathology the observations were made.

Method of experimenting.—A small animal, such as a cat, having been narcotized, the spinal cord is cut down upon in the upper lumbar region, at the junction of the dorsal and lumbar portions. A thread is passed through it for about an inch in a longitudinal direction. The ends of the thread are then tied, the wound stitched up, and the animal left for forty-eight hours. This gives abundant time for the excitement of inflammation. The animal is then killed and the spinal cord cut out.

Preparation of the cord.—The dura mater having been removed, the cord is cut into pieces of an inch long but not entirely separated from one another, so that their relative position is still indicated. These are placed in the following solution for twenty-four hours :

Chromic acid, ʒss ;
Methylated spirit, ℥xx ;
Water, ℥x.

Dissolve the chromic acid in the water and then add the spirit. Place in an extremely cool situation, or if possible in an ice chamber. Change the fluid every second day for the first week, and at the beginning of the second week place it in the following solution :

Chromic acid, ʒss ;
Methylated spirit, ℥x ;
Water, ℥xx.

Allow it to lie in this for another week, changing if a precipitate is thrown down. At the beginning of the third week change to the following :

Chromic acid, ʒss ;
Water, ℥xxx.

Change this every week until the end of the fifth or sixth, when the parts will be ready for cutting. This process is infinitely superior for all nervous tissues to anything that I have used, as the consistence of the tissue so hardened is tough instead of being brittle as in the old chromic acid method. For very large animals the solutions used are somewhat stronger. *Cut extremely thin sections with a micrometer screw apparatus,* fixing the cord in the hollow cylinder by a piece of carrot, punched out by means of graduated cork cutters. Stain with the following :

Carmine, ʒj ;
Liq. Ammoniæ fort., ʒj ;
Water, ℥iv.

Allow the sections to lie from five to ten minutes in this solution and then wash them in the following :

Acetic acid, ♏vj ;
Water, ℥iv.[1]

After this, wash them in pure water and place them in methylated spirit. Render them transparent with oil of cloves, and then mount them permanently in the following :

Gum Dammar, ℥j ;
Chloroform, ℥iss ;
Oil of cloves, ℥j.

---

[1] For all chromic acid preparations of the nervous centres it will be found that the specimens stain much more rapidly and thoroughly if the water in which they are washed is *slightly* acidulated.

Examination of the parts.—At the exact seat of the lesion caused by the thread the tissue was mechanically broken down and numbers of blood-extravasations were seen. The true inflammatory area, however, was not here, but at some distance from this in the surrounding parts, generally most marked in the deepest portion of the anterior columns, close by the commissure, and in the commissure itself. In some instances the whole extent of a transverse section was inflamed.

Changes in the Nerve-tubes.

By far the most remarkable change was that which had taken place in the axis-cylinders of the nerve-tubes (see Pl. XVI. fig. 1). On looking at a transverse section, numbers large round translucent bodies *deeply stained* were seen occupying the distended and attenuated nerve-sheaths. These bodies were usually five to ten times as large as the normal transverse section of an axis-cylinder, but, in many instances, reached even greater dimensions. Their formation was most beautifully seen in longitudinal sections. At regular intervals large oval tumours could be seen on the course of the axis-cylinders,[1] with attenuated portions of the original axis-cylinder still uniting them together (fig. 3). In many cases the axis-cylinder had quite given way, so that these large new formations came to have a separate existence, an existence as we shall see not calculated to end here, but to proceed to still further development. This condition was so remarkable as at once to arrest the attention, and in certain instances, it was seen all over the section; in others it was localised to the most inflamed part. In some of the swellings concentric rings could be noticed, but, generally speaking, they had a translucent homogeneous aspect. On still closer examination one was struck with the remarkable fissiparous division which large numbers of them had undergone, producing little dépôts of similar round translucent bodies of smaller size (fig. 2). These lay at first closely together in aggregated clusters, but soon spread themselves out and invaded the surrounding tissues, leaving in their former site nothing but an empty distended nerve-sheath. In this stage they were exactly identical with the so-named colloid bodies so abundantly found in chronic nervous affections of the cord. Their size, shape, translucency, and especially their adaptability for being deeply coloured with staining reagents, were exactly similar to what every one must have

[1] Leyden ('Klinik der Rückenmarks Krankheiten') describes a similar lesion.

noticed in regard to colloid bodies generally, while the occasional appearance of faintly marked concentric rings was not inconsistent with their being identical. A little closer examination, however, enabled one to see a still further and more remarkable development which they underwent, especially in the neighbourhood of greatest inflammation, namely, that they lost their translucency, became transparent and granular, and that several nuclei formed in their interior. In fig. 4 is shown the formation of one of these large granular corpuscles. It is seen separating from the parent mass, *i.e.* from the contracted axis-cylinder, which latter shows a hollow space corresponding to the portion which has been lost.

These corpuscles now presented the appearance of "mother-cells," with numerous young cells in their interior (fig. 5). Last of all, in places where the inflammation had gone on to suppuration, these "mother-cells" were broken down, and the younger cells in their interior were set free as *pus-corpuscles* (fig. 5). Where the inflammation was not so acute the divided portions of the original axis-cylinders evidently remained as colloid-looking bodies resembling those seen in locomotor ataxia and other chronic nervous affections.

Changes in the Nerve-cells.

The most common occurrence which was noticed in these was a swelling or molecular transformation of the cell substance, by which its outline became indistinct. It was soon converted into a molecular mass, in which the nucleus usually remained for some time, finally, however, undergoing a similar degeneration. This is a condition which has been frequently described, and has been called by Meynert an œdematous affection of the nerve-cell. In no instance was fissiparous division of the nerve-cell noticed, but almost invariably the degeneration above described was present. In one instance there was a defined area about a line in length at a certain spot in the grey substance in which all the nerve-cells were so affected, and at the outer part of this area, where the degeneration was more advanced, their granular débris had disappeared, leaving a coarse network produced by the empty spaces, blood-vessels, and neuroglia. Swellings were seen on the processes of certain of the nerve-cells similar to what were seen in the medullary nerve-tubes.[1]

[1] Meynert has noticed such a lesion in syphilitic brains.

Changes in the Neuroglia.

This was not so markedly altered as one would *à priori* have expected; still in many instances its protoplasmic nuclei were much more abundant than in sections taken from normal portions of the same cord. The manner in which the new corpuscles were produced could not be made out with satisfaction, but the probability is, from what was seen, that they also resulted from fissiparous division.

Changes in the Blood-vessels.

In the neighbourhood of the ligature numerous and large extravasations were noticed, probably mechanically brought about in operating on the cord. In the pia mater surrounding the cord, and in the processes which run into it, immense numbers of round clear corpuscles were observed in the perivascular spaces and tunica adventitia of the vessels. They were also abundantly seen within the vessels, adhering to the inner coat, and many of them could be actually noticed in the wall. What these corpuscles were I think can hardly be a matter of doubt. They were the leucocytes of the blood, which, after adhering to the inner wall of the vessel in greater abundance than under normal conditions, made their way through its coats, passing into the perivascular space and adventitia, and there constituting pus-corpuscles. Throughout the grey substance numbers of similar corpuscles could be seen scattered indiscriminately, and there is every probability that these were also leucocytes which had wandered from the neighbouring vessels.

Having thus summed up the characteristic alterations in the individual tissues, their consideration shows us that the inflammatory condition in the spinal cord, like inflammation in other organs, is not one simple process, but is a combination of phenomena dependent on the individual characteristics of the histological elements entering into the construction of the part. The formation of colloid bodies from the axis cylinders, and their subsequent transformation into pus-corpuscles, were so clearly demonstrated as to leave little or no doubt on the subject, and it was a somewhat remarkable fact, in confirmation, that at the seat of greatest inflammation the division of the swollen axis-cylinders was most abundant, the segments becoming rapidly round, transparent, and granular, and further subdividing into pus-corpuscles. Where the irritation was not so great, the divided parts became round and translucent, but remained as colloid bodies, *i. e.* bodies which had a colloid-looking aspect. Much has been written about these so-called colloid bodies, but, so far as I am aware, their true nature has always been a matter of the gravest doubt, the current idea being that they result from a colloid transformation of previously existing protoplasm. This has always seemed a most indefinite and unscientific way of speaking of such matters, as the stages by which they arrived at this development have never been described, and why these, and none of the other tissues, should undergo colloid transformation has always remained unexplained. Wherever they occur, as in locomotor ataxia, the medullary sheaths of the nerve-tubes are generally distended, and their axis-cylinders are absent. This I have seen typically in several instances of the above-mentioned disease, similar lesions having also been described by many writers; and in an instance of syphilitic inflammation of the brain which I examined some time before making the above experiments, the appearances were so entirely similar that I beg to offer here a short account of them. The patient had suffered from a chronic cerebral affection accompanied with great pain, and was one day suddenly seized with hemiplegia, and died shortly afterwards. He had a distinct chronic syphilitic history, and there was every reason to suppose that the cerebral lesion was also dependent upon this diathesis. At the *post-mortem* examination every part of the brain was found comparatively healthy except the vessels at the base and a portion of the pes pedunculi on one side. In this latter situation was a dirty red softened mass with a small extravasation in the centre, extending through the middle of the pes pedunculi, and for some distance into the tegmentum. On hardening the entire nervous centres and examining them with the utmost care, it was found that at the situation of the lesion described the vessels were greatly distended and their coats covered with thick translucent exudation composed of round corpuscles. In the centre of the pes pedunculi were seen blood-extravasations and broken-down nervous tissue, but around this *numerous large colloid bodies* of an oval or rounded form were seen arranged in a linear manner according to the direction of the fibres. They were very abundant, and, in many places, had undergone minute subdivision, the divided portions assuming a round and translucent aspect and constructing small depôts. Throughout the grey matter of the convolutions in many places, and in the region of the *nucleus lentiformis* on the left side, were scattered round transparent corpuscles distributed in an exactly similar manner to those seen in the grey substance of the spinal cord in many of the animals experimented upon. We may therefore conclude that this condition was a somewhat chronic inflammation of certain parts of the brain, and that in the pes pedunculi on one side, where it was most advanced, appearances were seen which were identical with those artificially produced in the above-mentioned experiments. In the medulla oblongata of epileptics I have also met with lesions which I now feel convinced were due to a chronic inflammation of the part, and in locomotor ataxia the absence of axis-cylinders, the distended nerve-sheaths, and the presence of large numbers of colloid bodies, all tend to confirm the hypothesis that we have here also to do with a chronic inflammatory affection.

The LIFE-HISTORY *of* PENICILLIUM. Translated and abridged from Dr. OSCAR BREFELD's 'Botanische Untersuchungen über Schmimelpilze,' Heft II. By W. R. M'Nab, M.D. Edin.; Professor of Botany, Royal College of Science for Ireland. (With Plates XVII and XVIII.)

AMONG moulds *Penicillium glaucum* is the one of most frequent occurrence. With unparalleled obtrusiveness the little plant forces its troublesome and unwelcome acquaintance alike on the learned and unlearned. Its pre-eminence among moulds depends less upon its size than upon its abundance, commonness, and highly characteristic pale blue colour. The fungus exists everywhere, and it is not possible by any observations to fix the limits of its geographical distribution. Its occurrence is dependent on no accident; it is the natural and necessary consequence of the ubiquitousness of its excessively minute conidia (asexually developed spores), which reproduce it with the greatest ease. The spores are scattered through the atmosphere, settling down when the air is still as a constituent of the dust; and they are then carried to the ground by rain,&c., from whence, on becoming dry, they are again lifted and carried by the faintest atmospheric current, if the place where they were first deposited was unsuitable for their germination. Thus the fungus obtains access everywhere; it is as unavoidable as the air by which it is carried. Out of doors it is to be found on all organic substances in a state of decomposition, more especially on the larger fungi. In our dwellings it is a real plague. Raw and prepared articles of food are exposed to its destructive influences. It moulds the cheese, the bread, fresh and preserved fruits, and many ways have been tried to destroy it or keep it under. It alone is the cause of many of our domestic arrangements, and much care must be taken during expeditions to prevent bread, flour, and other substances becoming mouldy. It is often content with the poorest food, which would be too bad for higher fungi. It lives in the human ear; it does not shun cast-off clothes, damp boots, or dried-up ink. Sometimes it contents itself with a solution of sugar with very little inorganic matter, at other times it appears as if it preferred the purest solution of a salt with only a trace of organic matter. It will even tolerate the hurtful influence of poisonous solutions of sulphate of copper and arsenious acid. No wonder that, as this fungus is so well fitted to be everywhere victorious in the "struggle for existence," it soon overcomes all other forms that come in its way. In the natural course of a spontaneous or artificial cultivation of mould the same tragedy is surely repeated. At first appear the statelier kinds of mould, the long-stemmed *Mucorini* and their allies, which fruit only on account of their more rapid growth. Among them Penicillium appears in three or four days; at first harmless and modest, in the form of delicate white specks of mycelium. These grow with fabulous rapidity in all directions, and form large patches spreading out and covering the whole substratum. But even before this takes place there are, as a rule, noticeable in the middle of each tuft, not higher than half a line from the substratum, small, alabaster-white, thick tufts, which are the conidia-bearing aerial hyphæ of Penicillium. From the centre of the cluster, and therefore from the centre of the whole group, begins a change from white into blue, which indicates the ripening of the spores. The blue colour spreads centrifugally over the whole patch, leaving only a white edge. At length even the edges becomes blue, and in from seven to ten days the whole substratum is covered with a blue coating, which, on the slightest agitation, gives off clouds of spores. When the whole substratum is exhausted the culture of the Penicillium ends. Other fungi have no chance of growing during the period of vegetation of the Penicillium, and any subsequent development in the exhausted nutrient substance is impossible. Penicillium is the plebeian despot among the moulds—mould *par excellence*, and the form meant when we use the word mould.

Penicillium was undoubtedly long familiarly known before it received any scientific notice, as its minute size would prevent its examination until sufficiently high magnifying powers were available. Micheli[1] was the first to do so in the year 1729, and he gives on Plate 91, fig. 3 of his work a correct representation of Penicillium, which he called *Aspergillus albus.* It is of interest that Micheli correctly separates Penicillium from *Aspergillus glaucus,* which is easily recognised in his fig. 1; he, however, unites Penicillium with a number of other moulds in his genus Mucor. Linnæus in his 'Species Plantarum,' thirty-five years later, described Penicillium under the name of *Mucor crustaceus albus.* In 1801 Persoon[2] described a fungus, which is undoubtedly Penicillium, under the name of *Monilia digitata.* Link first firmly established Penicillium as a new genus of fungi, and he is the author of the name now in common use. He carefully separated Penicillium from Aspergillus, and further set aside the specific name *crustaceum* given by Linnæus, and replaced it by *glaucum.* In 1829 Fries reinstated the Linnean specific name, and in 1846 placed Penicillium in the *Mucedines* in opposition to the *Mucorini.* Subsequent authors, as Bolton, Corda, and others, describe the fructification of Penicillium, but it is not till 1869 that E. Loew[3] describes the germination of the spores, the growth of the mycelium, and the development of the conidiiferous hyphæ.

A new impulse and direction was given to the study of the fungi when, in 1851, Tulasne discovered the pleomorphism of the reproductive organs—a subject the investigation of which was further prosecuted by De Bary. Penicillium, being an abundant and common form, became of great importance in the study of the supposed pleomorphism, and truly marvellous results followed.

Bail, in 1856, announced that spores of Penicillium, when sown in mash, grow like yeast, instead of producing mycelium. Hoffmann, Turpin, and Berkeley followed in the same direction, the latter considering that yeast was a peculiar condition of certain moulds, particularly Penicillium, which no longer produced fruit, and, further, he believed that he obtained Penicillium by the germination of yeast-cells. A little later Joly and Mousset thought they had confirmed the idea that Penicillium was the fruit of yeast. In 1861 Pouchet stated that yeast was an incomplete plant, and really the spores of Aspergillus; but three years later he changes his opinion, and says that yeast consists of spontaneously generated spores, which, when they germinate, produce Peni-

[1] Micheli, 'Nova plantarum genera juxta Tournefortii methodum disposita.' Florentiæ, 1729.
[2] Persoon, 'Synopsis Methodica Fungorum.'
[3] Pringsheim's 'Jahrbuch,' vol. vii, p. 472.

cillium. Trécul, in 1868 and 1869, tried to show that Penicillium, Mycoderma, and Torula were different forms of the same species, and in 1871 he attempted to trace back the formation of Penicillium. According to his views, albuminous materials change into Bacteria, or directly into yeast and Mycoderma, or the Bacteria change into the lactic acid ferment; this develops into yeast, then into Mycoderma, which lastly becomes Penicillium.

In 1865 Hoffmann invented his apparatus for cultivating these fungi, and this directed observations into a new channel. According to Hoffmann, yeast was a typical unicellular fungus —a special vegetative form of the mycelium of Penicillium glaucum, or more rarely of Mucor racemosus, sometimes of both, or even of other moulds, the access of atmospheric air being necessary to cause the fructification of the yeast to assume the form of Penicillium. Bail closely follows Hoffmann, and obtains Penicillium and Mucor from yeast.[1] Under water the spores of Penicillium and Mucor produce Torula; on the surface of fluid mycelium and conidiiferous hyphæ are formed. Bail also states that if flies eat yeast they become affected with Empusa if their bodies are under water, with Achlya if the body is on the surface, while the portion of the fly above the water produces Mucor.

Hallier stated that when Penicillium grows on a definite nutrient substratum it produces Penicillium only, and if other forms of fruit are developed it is on account of a change in the conditions. Thus, on moist bread Mucor develops from Penicillium; on milk, Leptothrix; and from Leptothrix, Torula. The development shows that the genera Penicillium and Mucor must be united, and that five other genera must be suppressed, viz. Achorion, Leptothrix, Hormiscium, Cryptococcus, and Trichophyton. By different nutritive materials eight different things can be got from Penicillium. If the spores of Penicillium are placed in water they rupture, and the granular contents escape in the form of small moving particles (Micrococcus, Bacterium), which come to rest after repeated division and form a single-jointed thread. In 1868 and 1869 Bail and Hoffmann published other papers on the relations of yeast and mould.

In 1870 Reess examined yeast, and declared it to be a

[1] Professor Huxley, however, has found that when *submerged* in a saccharine liquid "the mode of development of the younger hyphæ becomes changed. They break up, by a process of constriction, into short lengths, which separate, acquire rounded forms, and at the same time multiply after the manner of *Torulæ*. Coincidently with these changes, an active fermentation is excited in the fluid, so that this '*Mucor-Torula*' functionally, as well as morphologically, deserves the name of yeast."—EDS.

definite unicellular fungus, and described the formation of ascospores. He, however, incorrectly stated that yeast-like cells could be produced from *Mucor racemosus* and *M. Mucedo.* Cohn has recently shown that there is no proof whatever that Penicillium and Bacteria have any connection. Indeed, the strange results mentioned above by so many different authors nearly all proceed from imperfect observations and a misapplication of the facts of pleomorphism.

I. *Asexual Reproduction of Penicillium by Conidia.*

The conidia or asexually produced spores of Penicillium are very minute, and measure only 0·0025 mm. Magnified 300 diameters, they appear to the eye as small round points with strongly shaded margins, like the fine particles in a fluid which has been frequently filtered but is still turbid. The highest magnifying powers afford no means of giving a better description. No contents are observable, no membrane can be seen surrounding them, and the outer surface shows no irregularities. Turn them as you please, the mark of the points of attachment cannot be detected; they show, however, so many variations from the spherical form that they can hardly be called round.

If a single spore be placed in a clear solution of an organic substance remarkable changes immediately commence. The spore swells up considerably and regularly in all directions. Now, for the first time, the contents become visible, and the delicate smooth membrane surrounding them. The contents consist of very finely granular protoplasm, which appears to fill the cell uniformly. By very careful adjustment one or more very minute vacuoles may be brought into view, which in general do not fuse together to form a large one. The swelling of the spore does not exceed three times that of the unaltered one, and at this stage germination takes place, sometimes one, sometimes two to six, projections forming in different directions. These are always narrower than the swollen spore, which renders them easy to recognize, even at the first glance. The projections are so regular in width that they look as if formed to pattern. Growth occurs, apparently, only at the apex of the hypha to which the projection gives rise. The hyphæ soon cease to be unicellular, transverse septa forming at irregular distances from the apex. It is now possible to distinguish the terminal cells from the rest, since the end-cell alone grows in length, a subsequent intercalary extension of the cells of the hyphæ when once fully formed never occurring. The end-cell is capable of forming lateral branches at different parts, and these appear so near to the apex that for a short time they appear as if formed by dichotomy—which is never the case—instead of being monopodial. While the end-cell grows and forms branches, the older hyphal cells, which have ceased to grow in length, form new lateral branches. These have a definite position, and are generally formed immediately below a transverse septum. On the branched hyphæ, which constitute the mycelium, there are two kinds of lateral branches—the one formed by the branching of the end-cell, and inserted about its middle, while the others are lateral branches of the hyphal cells, and are inserted close to the septa. It is not necessary, however, for the hyphæ to branch, and in many cases both kinds of branching may be arrested and long single threads be produced in consequence. The lateral branches have the same monopodial mode of development as the main axis. The whole system of branches of the mycelium develops centrifugally from the spore as a centre. At the first glance we observe that throughout the mycelium the hyphæ are of the same thickness, and when first formed the side branches are of the same thickness as the main axis, the youngest side branches being, when first formed, of the width of the main branch. The diameter of the hyphæ varies in different cases, being about 0·0071 mm., and when poorly fed the diameter may only be about 0·0040 mm.

The contents of the mycelium resemble those of the germinated spore. They consist of an exceedingly finely granular protoplasm with very small vacuoles. When magnified less than 300 diameters the hyphæ are strongly refracting, but cease to be so when dead. Violent shaking causes changes in the large rank mycelium, the hyphæ rupturing near the apex by endosmotic action. The protoplasm escapes at these places, changes its appearance, and becomes dark and granular, but does not mix with the nutrient solution in which the mycelium lies, like the protoplasm of the higher plants. A wall soon forms round the protoplasm, and its further escape is prevented. This growth is somewhat like the formation of cork in wounds of higher plants. Brefeld has also observed a similar process in the mycelium of Mucor and Entomophthora muscæ.

It is a special peculiarity of the mycelium of Penicillium that at certain places the hyphæ fuse together and anastomose. The fusion is only seen properly in small, slightly branched mycelium, and when the hyphæ are isolated and not matted together. Loew thinks that defective nutrition is the cause of this fusion, but the phenomenon is one of minor importance.

Penicillium begins at a very early stage to produce conidia, even when the mycelium is growing rapidly. This production takes place more or less rapidly, according to the external conditions. If the mycelium is near the surface of the nutrient fluid, and obtains access to the air, conidia are produced sooner than when the mycelium is deeper. The earliest appear on the third day, the latest on the fifth after sowing the spore. No marked change in the mycelium precedes the process; special branches are not formed, and it is only those hyphæ that rise into the air that form spores. They are, therefore, not specially formed branches, and have the same position as the lateral branches of the mycelium, while in thickness, 0·0047 to 0·0050 mm., they do not differ from ordinary hyphæ. The conidiiferous hyphæ generally appear first on the older parts of the mycelium, and, therefore, in the centre of patches of it. In general they are inserted behind a transverse septum, and may be the youngest lateral branches which are produced perpendicularly to the substratum, and first reach the top of the fluid in the centre of old mycelium; frequently many of them are placed close together. After the development of conidia has commenced the individual hyphæ grow over all parts of the mycelium exactly as before, the end-cells increase the circumference by apical growth and branching, while the hyphal cells form branches and increase the number of threads in the centre of the mycelium. As growth goes on and conidia are developed, it ultimately becomes impossible to observe the spore from which the whole system was developed.

The hyphæ which produce conidia very soon cease to grow in length, the apical cell ceasing to grow after a septum has formed a short distance from the apex. Immediately below the last septum the youngest cell of the thread forms a lateral branch, the end-cell of which turns vertically upwards. Before this has attained its full height the main axis of the hypha forms a projection like a portion of the hypha, but which is a spore-forming basidium (or conidiophore). The apex is narrowed into the sterigma, which enlarges at its end into the first spore (conidium). Beneath the first another forms as soon as it attains its normal size, then another, and so on until a chain of spores is produced as in Aspergillus, Cystopus, &c., the apical spore being the oldest, that nearest the sterigma the youngest. The spores when first found are colourless, but soon assume a bluish colour (turning to sage-green when dry), which is not noticeable in the single spores, although evident when they are in the mass. At the time the basidium on the main axis forms its first spore, a basidium forms on the lateral branch, which in turn begins to form spores. At the same time a second and third basidium form at the apex of the main axis and also on the lateral axis, so that in a few hours the formation of spores is proceeding on all. Two cases of formation of spores are figured by Brefeld.

The spores in the chain are not all of the same size; they decrease in size from the apex to the sterigma. At first this is well marked, but later it is not so distinct. Between the spores the small connecting neck remains for some time, and unites the spores into a chain; this disappears when the spores fall off, and leaves no trace of its existence. The neck is a short portion of the sterigma which remains between every two swollen parts, either permanently, as in Cystopus, or for a short time, as in the present instance, and Aspergillus. Loew thought that there was a special membrane outside the true wall of the spore which formed a neck between the spores; but Brefeld considers this a mistake and distinctly states that the wall of the spore is single.

If the spore be germinated in a very rich and concentrated nutrient solution it produces many hyphæ, which branch frequently and form so thick a felt that the mycelium resembles a skin and can be raised from the solution as a firm, tough layer, like soaked cartridge paper. The thickness of the layer of mycelium depends on the number of the branches which come to the surface to form spores. These are placed so close together that the spore-forming basidia give rise to a kind of crust; hence the Linnean name *crustaceus* applied to the species. The growth of the mycelium and formation of spores are unlimited, and continue as long as the nutrient material lasts. Sometimes the dense aerial hyphæ unite into bundles and form an almost tree-like fungus, the crown being formed of numerous closely aggregated, spore-forming basidia. This form of Penicillium, which is only found when the plant is rankly nourished, was described by Link as a special fungus under the name of *Coremium glaucum*.

When the spore is germinated in a solution poor in nutrient material, as in water with a minute trace of organic matter, it only sends out one hypha, which is narrower than usual and grows very slowly. The branching is scanty, and only after many days the mycelium first sends up a branch to the surface which bears spores. Occasionally, after a long struggle for existence, the single hypha developed from the spore becomes itself aerial and spore-bearing.

It is not difficult to obtain an idea of the varying forms and development of the aerial hypha depending on the nutrition. In the simplest case, when very poorly nourished, a basidium forms at the end of the hypha, and thus a single row of spores is produced. Brefeld only observed one such case as this, although single basidia were sometimes observed on mycelia which produced other hyphæ with six to eight basidia. As a rule the hypha branches, as we have seen, the first lateral branch being formed immediately below the first septum. It develops from twelve to sixteen basidia, and is as fruitful as the apex of the main axis of the hypha; from the same hyphal cell from two to eight branches may be formed, all of which grow to the same size as the main axis, and render it indistinguishable. The aerial hypha in this case produces a rosette of branches at the apex, all inserted at the same height, and each branch ending in rosettes of a variable number of basidia. But the development rarely stops at this stage. In general a branch is produced immediately below the second septum from the apex, and grows to the same height as the axis; it divides by a transverse septum into a terminal and a lower cell, which develop side branches like the main axis, or very rarely remain sterile. The number of cells may be equal in both or not. Lastly, the third joint-cell of the main axis may develop a system of basidia. As a rule the lateral branches alternate in their position, being placed right and left, and they develop more basidia the further they are from the apex. The conidiiferous hyphæ thus develop centrifugally, in opposition to the mycelial hyphæ, which have an apical development.

II. *Sexual Reproduction of Penicillium.*

In all the instances of the culture of Penicillium yet studied the development never proceeded beyond the asexual formation of conidia. Other mycologists, as De Bary and Tulasne, obtained the same results; and Brefeld himself tried the conidia-spores in every kind of substratum. At last he employed bread as a substratum, as he had found it very useful in his researches in the *Zygomycetes.* A flat piece of common coarse bread (not sour) was taken and the spores of Penicillium placed on the under surface. Water from a wash-bottle was then directed on the spots where the spores were, in order to render the bread moist and to force the spores more into the interior. When so treated the bread was placed with the spores downwards on a flat surface, and the whole was carefully covered over. After about three weeks the blue-coated bread was lifted, and on the under side, here and there among the vigorous white mycelium, small protuberances were observed, more or less aggregated in little heaps. They could be readily separated from the white mycelium, and then appeared as solid hard bodies, not quite round in form, and resembling yellow grains of sand in size and colour. Internally they consist of a normally formed, colourless tissue of thick-walled cells, which are best seen in thin cross-sections. The tissue possesses all the characters of vegetable cellulose, the thickness of the walls indicating that the part was in a resting stage (Plate XVII, fig. 5). In all probability this plant could be no other than Penicillium itself, as other fungi were believed to be excluded. New experiments, which were quickly repeated in the same manner, confirmed the results and showed that Penicillium had a sclerotium-form like many other fungi. Several questions now arose for solution, such as—How was this body formed? Was it the result of sexual generation? What was its physiological signification? what would be developed from it? and could it be clearly demonstrated that it belonged to Penicillium?

Sclerotia of Penicillium had been already described by J. H. Leveillé[1] in 1840. He observed small yellow bodies, which he took for sclerotia, on very old tamarinds, on which Penicillium was growing; but he does not seem to have paid much attention to them. To Brefeld, therefore, is undoubtedly due the credit of having pointed out the true relation of this structure to Penicillium.

Brefeld placed Penicillium-spores in the manner already mentioned on both sides of a flat piece of fresh bread half an inch in thickness, and let a few drops of distilled water fall on it and be absorbed. On the third day the piece of bread, which was lying free under a bell-glass, was gently moistened, and on the following days well watered with a wash-bottle. From the sixth to the seventh day, according to the temperature, the development of the mycelium was so energetic that the temperature of the air in the bell-glass was raised, while that of the bread reached 111° F. At this

[1] "Sur les Sclerotium," 'Annales des Sciences Naturelles,' (2e série), tome xx, 1843.

stage, before the formation of any conidia was noticed, the bread was placed between two glass plates *to prevent the access of oxygen* and the formation of the ordinary conidiiferous condition of Penicillium.

The sclerotia began to appear on the seventh day, and were easily observed with a lens magnifying twenty diameters as white spots. As the youngest stages could not be so readily observed, thin slices were made and coloured with aniline, which brought out the young sclerotia very distinctly. The earliest observed stage that could be distinguished was a spirally-twisted structure, seated on a thick short-celled hypha. The spirals consist clearly of two different cells which are thicker than ordinary mycelium, and their apices incline towards each other after having twisted one to one and a half times in opposite directions. These we must consider to be the carpogonium and the antheridium. Shortly after the entwining of these cells (the sexual organs), which much resemble those of Gymnoascus, one part of the spiral, which we must consider to be the carpogonium, begins to grow as a consequence of fertilization, and to form tube-like projections which in their diameter and contents resemble the mother-cell. At the same time the hypha on which the reproductive organs are placed begins to form numerous branches (Plate XVII, figs. 2 and 3). The growth of these is very rapid, and the whole carpogonium is surrounded and enclosed by them. The whole now appears as a mass of threads, even when rendered transparent with glycerine, ammonia, or caustic potash.

At the time the carpogonium became imbedded in sterile hyphæ it had already begun to form branches. A section of the young sclerotium (sporocarp) shows the carpogonium as a branched mass in the centre of the sterile hyphæ (Plate XVII, fig. 1); it (fig. 1 *a*) can at once be distinguished by the size of its hyphæ. The sterile hyphæ (fig. 1 *b*) have only a diameter of from 0·0030 to 0·0040 mm.; they are copiously and irregularly branched, and are constantly changing their direction, their septa being also very numerous. The carpogonium-hyphæ, on the other hand, are nearly twice as thick, being from 0·0050 to 0·0070 mm. in diameter; septa are absent, and the arrangement more regular. The hyphæ of the carpogonium as they grow interpenetrate between the sterile hyphæ. Outside the carpogonium-threads there are from eight to sixteen layers of these, varying in number according to the vigour of the plant. Outside the sterile hyphæ numerous hyphæ (fig. 1 *c*) are seen, which probably belong to the neighbouring mycelium.

In the next stage the sclerotium enlarges by the increase in size of the inner elements, the interstices between the sterile hyphæ becoming obliterated. The increase of the carpogonium-hyphæ now becomes difficult, and causes compression of the sterile hyphæ. The next change is the formation of a tissue from the cells of the sterile hyphæ. The carpogonium hyphæ can now be distinguished only by their filamentous nature, as they run among the pseudoparenchymatous tissue of the sclerotium. The cells of the pseudoparenchyma vary in size from the first, those near the carpogonium-hyphæ being smaller from the pressure of the growing carpogonium.

As soon as the growth in size of the sterile cells ceases the walls begin to thicken and the sclerotium to ripen. This occurs in from five to six days after their appearance, or in from twelve to fourteen days from the sowing of the spores. The thickening begins simultaneously in the sterile cells of the periphery of the sclerotium, and also internally in the carpogonium-hyphæ. The thickening of the sterile walls is accompanied by a change of colour, the yellow tint marking distinctly the boundary of the sclerotium. The sclerotium now no longer takes up nourishment from the outside, the substance for the thickening of the walls being supplied by the cell-contents, which consist, at the beginning of ripening, of almost homogeneous protoplasm. The thickening goes on for from six to eight days, and when completed the cells are nearly empty. The external white covering of mycelial hyphæ now ruptures, and the coloured sclerotium appears in view, with its rough, uneven surface. The sclerotia (Plate XVII, fig. 4) vary much in size and form, and are either separate (fig. 4 *a*) or united in small groups (fig. 4 *b*) of from two to ten. Some of the sclerotia measure 0·870 mm.; others are only from 0·165 to 0·230 mm. They are hard and firm, and cannot be easily crushed, and from the thickness of the cell-walls thin slices for microscopic examination can be easily cut. The carpogonium-hyphæ are then seen to form a series of branches, which spread irregularly in all directions from the original carpogonium as a centre towards the periphery of the sclerotium, and end at different distances from the surface.

Briefly to recapitulate, we notice the following facts:—The sclerotia are formed on the mycelium of the sexual stage of Penicillium. They are products of a sexual process. They contain the germ of the second generation, produced from the fertilised carpogonium, and this germ, up to a certain stage of its development, remains inactive, in the form of a much-branched, hyphal system, in the middle of a tissue which is not directly of sexual origin, but stands in close relation to the sexual act, and is a consequence of it. This tissue is descended from the hyphæ of the sexual generation, and forms a protecting covering to the young germ, and, as we shall presently see, serves for its nourishment. The greatly thickened cells and the protection externally by cork-cells indicate a condition of permanence and rest; in this condition the structure may be termed a sclerotium. In its mode of origin and nature the sclerotium of Penicillium agrees in its general characters with the endosperm-bearing seed of the higher plants. The seed contains the germ (embryo) of the second asexual generation, and a sterile tissue belonging to the sexual generation. This sterile tissue is the endosperm on which the embryo lives at a later period after the termination of a period of rest, and when the conditions for germination are present.

In order to study the further changes, the sclerotia must be made to germinate. They were first washed thoroughly, to free them from all impurities, then placed on several layers of filter-paper, and covered with a bell-glass. The paper was renewed in from fourteen days to three weeks, and the sclerotia carefully washed. At first the sclerotia remained unchanged, except that the outer wall became dark brown. At intervals of three or four days the sclerotia were examined, but it was not until after five or six weeks that any change could be observed. The contents of the cells next the carpogonium-hyphæ became turbid; the small cells became withered, and their walls lost their shining and highly refractive appearance. This was only observed at certain parts near the centre of the sclerotia. The carpogonium-hyphæ develop septa, and become divided into short cylindrical cells (Plate XVII, fig. 5 *c*). These individual cells, which do not separate, now begin to branch in a peculiar way. A thick branch is formed, the apex and short lateral twigs of which coil up in a snail-like manner. At the same time a thin branch is formed from the same cell, which has the appearance of an ordinary hypha, and grows greatly in length, twists upon itself like a tendril, and forms similar lateral branches (Plate, XVII fig. 6). Many cells of the carpogonium-hyphæ produce no branches. Sometimes two or three cells lying together produce branches, at other times only one; and Brefeld was unable to determine whether the other cells subsequently produced branches or not.

Two forms of branches, of similar origin but of different kinds, are thus produced from certain cells of the carpogonium after cultivation of from seven to eight weeks. It is an undoubted fact that the thinner ones consume the sterile tissue of the sclerotium (Plate XVII, fig. 5 *g*). The walls of the cells in the neighbourhood become thinner and disappear, and these branches must be considered to be special organs of nutrition. They are closed at the ends, and dissolve the tissue of the sclerotium and take up the nutrient substance in some unknown manner. The fertilized carpogonium thus lives as a parasite in the centre of the sterile tissue, but at no point has it any organic connection with the sclerotium.

The thinner nutritive carpogonium-hyphæ elongate by apical growth and increase by branching (Plate XVII, fig. 5 *d*), so as to form a filamentous investment round the thicker tubes. As they grow the scope of their activity becomes greater, and increasing nutrition keeps pace with the growth. As long as the nutritive hyphæ are active they possess few or no septa. Their course is irregular; in many places they form dilatations, the cavity being double the ordinary width. Numerous twists and tendril-like turnings alternate with straight portions, and constricted parts are followed by dilated portions, and, again, these are suddenly followed by contractions. The diameter is from 0·0015 to 0·0025 mm., the wide portion being about 0·0050 mm.

The thick branches—those destined to form the fructification—have a very slow growth, but produce very numerous branches. The first lateral branch is formed close to the apex and elongates, others forming which are packed closely together in a coil. From the frequent branching and the slight growth in length, the whole looks like the mode of branching in yeast; it, however, follows a regular plan. Only the ends of the hyphæ can be observed, but there can be little doubt that the development of the other parts follows the same course. The short apex bends to one side in a somewhat snail-like manner, and on the convex back of the bent hypha the youngest branch is always developed. The main axis next turns about two thirds of a revolution to the opposite side, and another lateral branch is developed. This process, frequently repeated, must ultimately cause the formation of a serpentine main axis, on which the lateral axes are placed at very short intervals. As regularly as lateral branches are formed, so regularly are transverse septa developed in the main axis, the youngest being always above the third youngest lateral branch; and as each new turn is given to the apex of the main axis and a new side branch is formed, a new transverse septum is produced. Thus a main axis is formed, consisting of short twisted cells, each one of which bears a lateral branch. The lateral branches may behave like the main axis, and form similar secondary lateral branches. This, which frequently happens at the early stage of growth, is quite exceptional at a later period. The primary lateral branches may grow at the apex and twist, but without forming secondary lateral branches. The axis is thus simply branched, the lateral branches being unlike the main axis, and this condition is the rule during the later stages of development. The serpentine turnings of the main axis may assume a more or less regular spiral form, or may grow for some time in one plane, so that the lateral branches appear right and left in a bilateral manner.

As the simple lateral branches of the main axis grow immediately after their formation close to the apex of that axis, and as that apex grows very slowly in length, it becomes rather difficult to determine what is a lateral branch and what is the apex of the main axis. At a certain stage the apex looks as if it divided dichotomously with excessive development of one arm of the fork. The apex of the lateral branches which remain unbranched becomes curved, showing that the curving is not caused by the formation of lateral twigs. As the branches increase in length their older parts increase in thickness. The enlargement is greatest at certain parts, so that the thread consists of undivided rounded portions, joined so as to look like a row of yeast-cells. These swellings follow one another without any appreciable isthmus between them. The basal part of each branch, however, remains small, like a stalk, bearing the first swollen portion (Plate XVIII, fig. 8). Probably from eight to ten pear-shaped swollen bodies may develop on a branch.

The unbranched, simple lateral branches are for reproduction. Each of the globular swellings becomes an ascus. When the swelling is complete a septum forms in the narrow isthmus between each of the swellings. As the isthmus of the basal part is long, and the septum forms close to the swelling, a sac-like projection of the main axis remains. After the separation of the swellings the contents of the pear-shaped bodies change (Plate XVIII, fig. 9). The uniform contents are broken up by the formation of a large central vacuole, which disappears, and in its place several smaller vacuoles appear. In the next stage the spores are present. The object is far too small to permit the whole process of spore-formation to be observed, but there can be little doubt that the process is similar to that observed by De Bary in Eurotium, and by Janczewski in Ascobolus. Darkening of the margins of the young spores indicates the formation of the cell-wall, and when the ascus is fully developed it contains eight spores, without any trace of protoplasm remaining unused (Plate XVIII, fig. 9).

When the spores are ripe the string of asci breaks up, and only the little stalklet of the branch remains attached to the main axis (Plate XVIII, fig. 10).

In the sclerotium (sporocarp), therefore, we have the carpogonium-hyphæ developing two morphologically and physiologically distinct elements; the one developing the asci and ascospores, the other serving as nutrient organs and taking up nourishment from the substance of the sclerotium itself. During the consumption of the sterile tissue of the sclerotium crystals are formed near the margins of the parts being destroyed. These crystals consist of calcium oxalate and often form regular octohedra (Plate XVIII, fig. 7 *e*). This formation of crystals of calcium oxalate is of the same physiological importance as the formation of similar crystals in the higher plants.

The consumption of the sterile tissue keeps pace with the development in the interior of the sclerotium, being remarkably slow for a fungus. It may take entire weeks to observe any progress. As the asciferous hyphæ spread from the centre by the growth of the numerous apices of the threads spores are developed in regular succession. Then as the asci ripen they fall off and the spores are set free by the disappearance of their walls (Plate XVIII, fig. 7 *f*). After the germination of the sclerotium spores may be observed in its central part in from four to six weeks, while the last-formed asci in the periphery only form ripe spores about five months afterwards.

At last the sterile tissue of the sclerotium is reduced to a mere wall two or three cells thick, of small, slightly elongated cells of a brown colour. The cortex of brown cells, which are partly corky in composition, remains undissolved, and serves as a firm investing-capsule. When all the nutrient substance is absorbed all the hyphæ and asci which were near the margin disappear, as they had done in the earlier stages in the centre, and there remains now only a mass of spores, intermixed with crystals of calcium oxalate, and surrounded by the firm yellow-brown capsule. When the capsule becomes dry, in the course of time it ruptures, and the innumerable minute spores are set free. The spores have when in mass a pale-yellow colour, and a very regular form closely resembling that of the spores of Eurotium. In form they are elongated, rapidly narrowed towards both ends (Plate XVIII, fig. 11). On cross-section they appear round, with lateral projections which give them a star-shaped appearance. They possess a double wall, the outer, a thick ornamented exosporium consisting of two valves separated by a deep groove running from pole to pole of the spore. Each valve has three or four ribs on the dorsal surface, which project but slightly. The spores are 0·0050 to 0·0060 mm. long, and 0·0040 to 0·0045 mm. broad.

When the sclerotia begin to ripen they change their colour, losing their brown tint, becoming paler, then yellow like the spores. The time elapsing between the formation of the sclerotia and their ripening is about from six to eight months. The smallest sclerotia germinate as well as the large ones, as also do the cohering ones; in the latter case, however, only a single cavity containing spores is formed. The sclerotia can be dried for some time without losing their vitality, but if dried for more than three or four months they were killed.

It remains now only to show that the ascospores again produce Penicillium. The ascospores were sown in a carefully filtered decoction of dried plums, or in a decoction of red currants or gooseberries. The germination occurred in from eighteen to twenty-four hours, and was very characteristic (Plate XVIII, fig. 12), resembling the germination of the spores of Eurotium. At first the exosporium ruptures by the swelling of the contents of the spores, but it is not thrown off, the endosporium protruding like a sac to one part of which the exosporium remains firmly attached. The presence of the exosporium at once characterizes the germinating ascospore, and renders it impossible to confound the germinating ascospores with germinating conidia. From the swollen endosporium one or two germinating filaments are formed, and from these the mycelium springs. The mycelium which is produced from the ascospores agrees in mode of growth, branching, division by septa—indeed, in every detail—with that developed from the conidia, so that the description of the one applies equally to that of the other. Next day the mycelia develop conidia as in ordinary Penicillium-mycelia.

The ascospores retain their vitality for a very long time. After being kept dry for two years a few ascospores germinated, but most of the spores had fallen into two halves.

The conidia lose their power of germinating in from one and a half to one and three quarter years.

The life-history of Penicillium may thus be shortly summed up:—From a spore of the second (asexual) generation, that is, from an ascospore (or a conidia-spore), there is developed a large mycelium which bears the reproductive organs, the carpogonia, and antheridia, and is the first or sexual generation. After fertilization the second generation begins and is a sexually produced but *asexual* plant. The destruction of the first generation does not immediately take place, but at first the second generation remains in direct connection with it and is nourished by it. It is at the same time surrounded by a nutrient tissue, which is formed from the sterile hyphæ, and is later separated from the mother-plant in the form of a sclerotium (sporocarp) which may be compared physiologically to a seed. After a longer or shorter period of rest the second generation grows, living as a parasite on the nutrient tissue belonging to the first generation, and forms an asexual plant which develops asci and ascospores. From each spore of this second asexual generation there proceeds, as we have seen, the first or sexual generation.

The conidia are not directly connected with the alteration of generations, and represent only a mode of asexual reproduction. In Penicillium the alternation of generations consists only of two stages. The first or sexual generation is large and capable of producing asexual spores, the conidia, which resemble the gemmæ of the Liverworts and Mosses. The second or asexual generation is small and lives as a parasite on the nutrient tissue which surrounds it. The formation of the ascospores shows that Penicillium must be placed in the great group of the *Ascomycetes*, and there can be little doubt that, from the striking resemblance of the minute structure of the sclerotia of Penicillium to that of the *Truffle*,[1] the former must be placed close to the *Tuberaceæ*.

[1] See Sachs's 'Textbook of Botany,' p. 255. Some figures and a rather poor account of the structure will be found in the 'Popular Science Review' for 1862.

The Resting-Spores *of* Peronospora infestans, Mont. By Worthington G. Smith, F.L.S. (With Plates XIX and XX.)[1]

The two accompanying photographs (Plate XIX) were taken from nature by the aid of the microscope on July 31st last. They represent the oogonia and antheridia of *Peronospora infestans*, Mont., from one of the tubers of the American potatoes grown this year in the garden of the Royal Horticultural Society at Chiswick. The whole plant experimented upon was badly attacked by the Peronospora, and on the tuber being cut into halves the exposed surfaces became covered with the normal fruiting branches of the now well-known fungus. On these tubers being kept under glass for further experiment a condition of watery decomposition at once set in, and the tubers and water alike were infested in every direction by hyphæ, oogonia and antheridia, similar to those here figured. I regret that I lost the greater part of the material from this individual tuber, as one half of the specimen suffered from too much moisture and the other half from too little; every one acquainted with moulds well knows that the least superabundance of moisture or the least drought at once destroys the mould. The bodies here photographed were those present in the turbid fluid which oozed from the Peronospora-infected tuber, and the whole of this liquid I have preserved intact. For three or four days after the exudation had been placed in a phial these reproductive bodies floated, grew, and united in pairs on the surface; but after the lapse of a week they all descended to the bottom of the phial, where they have ever since remained. Before the phial was sealed repeated experiments were made with a test-tube, before many other observers, to show that the fecundated oospores were present in abundance at the bottom of the liquid.

The photographs which accompany this paper are two of the best of a series of a dozen, and they were all taken

[1] The state of our knowledge of the life-history of *Peronospora infestans*, previously to Mr. Worthington G. Smith's important observations, is summarized in the 'Quart. Journ. Micr. Sc.,' 1874, pp. 176, 177. Prof. De Bary's recent investigations led him to the conclusion that the sexual state might occur on a separate plant. ('Nature,' vol. x, p. 390.) This view has also been maintained by Mouillefert and by H. Jenkins ('Journ. Roy. Agric. Soc.,' 1874, p. 510). We understand, however, that Prof. De Bary has now abandoned it, and has recently obtained results entirely confirmatory of those of the author.—Eds.

under great difficulties, ten negatives at least being failures before one satisfactory result could be obtained. The difficulties which presented themselves were manifold, the first and most insuperable being the dull and cloudy weather; this obstacle was made worse by the semi-opaque material in which the bodies photographed were found. At sunny times characteristic material could seldom or never be found, or the photographs would have been better. In looking at an object under the microscope the focal distance is constantly being slightly altered, so that different depths may be seen, but in photography the instruments must be stationary; the consequence is that part of the object must always be slightly out of focus. Besides this, unless lenses are specially made the luminous and chemical rays have a different focus, or are not coincident.

Plate XX, however, sketched by the aid of a camera lucida at the time the objects were photographed, furnishes a key to the position of the oogonia and antheridia and hyphæ seen in Plate XIX. The single oogonium at J, lower figure, was burst during the moment occupied in taking the photograph by the concentrated rays of the sun being sent on the object from the reflector of the microscope. To all acquainted with similar bodies found amongst other moulds, in Algæ and some Saprolegnieæ, these photographs and the accompanying key speak for themselves.

The oogonia, antheridia, hyphæ, and mature oospore alike in *Peronospora infestans* are very similar in size, colour, shape, and habit to the same organs found in other species of Peronospora. The accompanying woodcuts (copied from De Bary[1]) show their appearance in *P. alsinearum* (Fig. 1) and *P. umbelliferarum* (Fig. 2). The mature resting-spore of *P. Arenariæ* is identical in every way with that of *P. infestans*.

One of the chief points of interest in connection with the discoveries made this year rests on the fact of the organisms here photographed being in every way identical with the bodies found thirty years ago by Dr. Rayer, Chief Physician of the Hôpital de la Charité, of Paris, and by him communicated to Dr. Montagne, who in turn forwarded them to the Rev. M. J. Berkeley.[2] These specimens are still in existence, and have been photographed to the same scale as the recently

[1] 'Ann. des Sc. Nat.,' 4me sér., xx (1863), pl. 8, figs. 10 and 11; pl. 4, fig. 15.

[2] Montagne described them under the name of *Artotrogus hydnosporus*. They are figured by Berkeley, 'Journ. Hort. Soc.,' vol. i, p. 33, t. 4, figs. 27, 28, 29.

found bodies and presented to every one known by me to be interested in the subject. All botanists know that Mr. Berkeley has from the first held to the belief that Dr. Rayer's

Fig. 1.

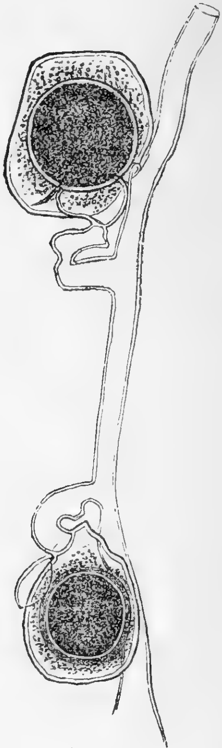


Fig. 2.

organisms belonged to the secondary form of fruit of the fungus which causes the potato disease, and recent observations have tended to prove the correctness of his views. At the meeting of the Royal Horticultural Society held on Sept. 1st last Mr. Berkeley exhibited a drawing made thirty years ago by Mr. H. O. Stephens, of Bristol, of a body (with hyphæ) found by the latter gentleman amongst the corroded cells of potatoes. Although this drawing was somewhat rude, it undoubtedly represented the mature resting-spore of *Peronospora infestans,* for it accords exactly in shape, nodular outer surface, colour, and size with the bodies more recently found. A reference to the numbers of the 'Gardeners' Chronicle' published last spring, in which the reports of the meetings of the Scientific Committee of the Royal Horticultural Society are given, will show that Mr. Berkeley was the first to detect mature oospores in the potato plant.[1] At one of these meetings he described the bodies, brought a sketch, and gave the exact dimensions. As Mr. Berkeley could find no trace of the Peronospora in the plants examined by him, he could not associate the two things together; but in the plants which came under my examination I found not only the normal Peronospora, but the mature resting-spores and the oogonia and antheridia in various stages of growth and in conjugation. The mature oospore is globose or slightly oval, brown becoming at length black-brown, and covered with nodosities; it measures from one seven-hundredth to one thousandth of an inch in length. A figure of it was published in the 'Gardeners' Chronicle' for July 24th last; it has also been illustrated in 'Nature'[2] and elsewhere.

OBSERVATIONS *on the* STRUCTURE *of the* SPLEEN. By Dr. E. KLEIN, F.R.S. (With Plate XXI.).

THE structure and function of the spleen has at all times been one of the most favourite subjects of discussion with histologists. It is chiefly its great importance in pathology that has made it an object of repeated investigation. The spleen is so complicated an organ, and its investigation combined with so many difficulties, that it is no wonder that even the principal points with regard to its structure are not yet definitely settled, being still a matter of controversy. Experiment has done very little hitherto with reference to the function of the spleen; the whole doctrine of its function rests, therefore, almost entirely on anatomical investigation. Generally the spleen is regarded as to a certain extent analogous to a lymphatic gland, in virtue of its containing masses of adenoid tissue, first in the sheath of arterial branches, and secondly as special elliptical or spherical collections—the well-known Malpighian corpuscles—in connection with small arteries. From this and from the fact that the trunk of the splenic vein always contains in the normal condition an abundance of lymphoid cells or colourless blood-corpuscles, it has been concluded that these cells are produced in the spleen.

[1] See June 19, p. 795 and July 10, p. 46. Mr. Berkeley at first took the oospores for a species of Protomyces.

[2] July 22, p. 234.

The spleen has been further regarded by some physiologists as an organ in which coloured blood-corpuscles are developed, and by others in which they are destroyed. Both theories are based on the fact that in the tissue of the pulp certain cellular elements—the pulp cells—are often found to contain coloured blood-corpuscles. The latter of these two theories is, in addition, supported by the fact that some of the pulp cells, besides enclosing coloured blood-corpuscles, contain also particles of hæmoglobin and blood-pigment, thus indicating that coloured blood-corpuscles having been taken up by certain pulp cells (probably in consequence of these latter being amœboid cells) are destroyed by them, so that finally only amorphous blood-pigment is left. The latter doctrine has been, moreover, greatly advanced by the discovery that the blood channels of the pulp are not represented by a system of closed vessels, *i. e.* vessels with a special wall, but that the terminal branches of all arteries—those that enter the pulp of the spleen as such, as well as those in relation with the Malpighian corpuscles—break up into a labyrinth of spaces penetrated by a delicate nucleated reticulum containing also lymphoid cells—the proper pulp cells; on the other hand, the roots of the veins take their origin from those spaces. From this arrangement it is easy to understand that blood-corpuscles, while passing sluggishly through the labyrinth of the pulp, may be taken up by the pulp cells, and may become gradually destroyed. Likewise it can be readily explained why the efferent veins contain abundant colourless blood corpuscles; these, namely, being produced by the pulp cells, are simply carried away by the blood current, after having become separated from the pulp cells situated within the blood paths.

Wilhelm Müller, Frey, and others, are the chief representatives of this doctrine of the distribution of the blood vessels, against Billroth, Schweigger-Seidel, Kölliker, Kyber, and others, who maintain that the blood-vessels of the pulp, like those of other organs, form a closed system of vessels with a definite wall and lumen, and that the reticulum and the pulp cells—*i. e.* the parenchyma of the pulp—are always around, *i. e.* outside, the vessels.

The difference between the assertions of these two sets of authors is clearly a fundamental one, and doubtless that of W. Müller and Frey is much more favorable to the doctrine of the spleen pulp being concerned in the destruction of coloured and the production of colourless blood-corpuscles.

Billroth (Müller's 'Archiv,' 1857) was the first to describe the matrix of the pulp of the spleen as being composed of a reticulum of delicate fibrils analogous to the reticulum of the adenoid tissue. Frey and also Kölliker speak of this reticulum ('Manual of Histology,' partii, p. 451) as being very dense and composed of very delicate fibrils, which are, for the most part, non-nucleated, but occasionally, especially in young animals, contain nuclei, so that there can be little doubt that the reticulum develops into a network of connective-tissue cells. The meshes of the reticulum contain, according to Kölliker, the parenchyma-cells of the spleen in such a manner that often only one cell, occasionally two or three, occupy one mesh; the reticulum and its cells form continuous masses of splenic tissue between the larger blood vessels of the pulp, and are themselves penetrated by minute vessels. In the spleen of man, in which the minute veins form a very dense plexus, Kölliker goes on to say, the tissue of the pulp is, therefore, found to form a network of trabeculæ (the pulp-trabeculæ of Frey), and to fill up all the spaces of the venous network. According to the same author the parenchyma-cells of the splenic pulp represent spheroidal uninuclear cells, perfectly similar in appearance to those of the Malpighian corpuscles.

Kyber (Max Schultze's 'Archiv,' vol. vi, part iv, p. 596) describes the matrix of the splenic parenchyma as being composed of lymphoid cells enclosed in an intervascular network of fine fibres, in the nodes of which are found nuclei; they are scarce in old, more numerous in young, animals. "Besides the bright, sharply outlined fibres of this network a second network is found in hardened specimens, composed of finely granular fibres with notched edges and broad at some points. This is the intercellular substance of the lymphoid cells." In fresh specimens this intercellular substance appears to be tenacious and finely granular; it becomes more granular after the addition of acetic acid; the granules are, however, dissolved by the acid after prolonged action. This intercellular substance forms a part of the parenchyma, and extends into the lymphoid tissue of the arteries.

According to W. Müller (Stricker's 'Manual of Histology,' vol. i, p. 356), the splenic pulp consists of lymphoid cells and intercellular substance, the former being for the most part small and uni-nuclear, but sometimes larger and multinuclear cells, which stain more deeply with carmine than those of the Malpighian bodies. The intercellular substance, *i. e.* the substance connecting the lymphoid cells, is in the fresh condition a pale, transparent, very finely granular, tenacious substance, forming a delicate network between the protoplasm of the pulp cells. In chromic-acid preparations this appears like a network of homogeneous fine fibres, as described by other observers.

Thus it is seen that the intervascular network of fine fibres first described by Billroth and accepted by Frey, Kölliker, Schweigger-Seidel, Kyber, and others, as forming the matrix of the splenic pulp, seems, according to Müller, not to be a preformed structure as such, but to be rather produced by hardening reagents. The intercellular substance of Kyber, which is included in the intercellular substance of Müller, is different from this latter by being distinct from the intervascular network of fine fibrils.

With regard to the relation of the pulp tissue to that of the Malpighian corpuscles and the adenoid sheath of the arteries Schweigger Seidel and W. Müller, as well as Frey, maintain that both are identical; according to Billroth, however, and Kyber, both these tissues show more or less marked differences. Kyber finds that the pathology of the spleen proves the pulp parenchyma and the lymphatic sheath to be two different tissues.

Before I come to describe the results of my own investigations into the structure of the parenchyma of the pulp of the spleen I must say a few words in respect to the methods I employed. I used the spleen of rat, cat, dog, monkey, and man. I may mention here that the pulp of the spleen of the rat and the cat is similar to that of the dog, whereas that of the monkey is similar to that of man. For the investigation of the dog's spleen I use the following method :—Through the common trunk of the splenic artery of a freshly killed animal, (after ligaturing the small branchlets given off to the omentum) $\frac{1}{2}$ per cent. solution of common salt is injected into the spleen under gradually increasing pressure (from 60 to 160 mm. Hg.), until the fluid running out by the splenic vein appears perfectly clear and not to contain (for the unaided eye) any more blood, the whole spleen having become by that time swollen and pale, as is especially well seen on its edges. After this $\frac{1}{10}$ per cent. osmic acid is injected for about twenty to thirty minutes, beginning with 60 mm. pressure, and increasing it to 180 mm. The spleen is then placed, as a whole, in Müller's fluid. After eight to twelve days small bits are cut out, placed in alcohol for several hours, and used for preparing sections, which are stained and mounted in the ordinary way. The spleen of man is prepared in this way :—As soon as possible after death small bits are placed in a large excess of $\frac{1}{6}$ per cent. chromic acid, which is replaced by $\frac{1}{4}$ per cent., after six to eight days. After a few days more this is exchanged by ½ per cent., and finally the bits of spleen are placed in alcohol and used for sections, which are prepared in the usual way.

To begin the hardening with a stronger solution of chromic acid than $\frac{1}{6}$ per cent. is, according to my experience, objectionable, as stronger solutions tend to damage the material; for the same reason I do not think it advisable to increase the strength of the acid too soon.

I ought not to omit to add that injecting the spleen of the dog, as well as that of man, with Müller's fluid instead of osmic acid, after the injection with saline solution, is also a very good plan. Hæmatoxylin I found indispensable in my investigations.

As is very well known (Kölliker, l. c., pp. 449 and 450) the capsule as well as the trabeculæ of the spleen contain unstriped muscular tissue, the amount of which varies in different animals. With regard to man Kyber (l. c., p. 546) confirms the assertions of W. Müller, according to whom slender bundles of unstriped muscles exist in the capsule as well as in the trabeculæ. Meissner had also seen them in the spleen of man; Frey mentions them only in the trabeculæ, and several other authors, as Gerlach, Gray, Stinstra, Henle and Kölliker could not find any in the spleen of man.

This is what I find: in the dog the capsule contains in that half which is next the parenchyma a continuous mass of unstriped muscles, whose bundles are arranged parallel to the longitudinal axis of the whole organ; above this longitudinal coat there are small circular (*i.e.*, running in a direction parallel to the short axis of the organ) muscle-bundles embedded in a matrix composed of connective-tissue and elastic tissue, which latter forms, nearest to the surface, regular elastic laminæ. Near the somewhat sharp edges of the organ circular bundles are present also inside the longitudinal muscular coat. The trabeculæ are almost completely composed of muscles. In the spleen of monkeys the capsule contains a thin layer of longitudinal muscles in the deeper part only, whereas the trabeculæ possess a great amount of muscular tissue; at those places where the trabeculæ join the capsule, they (the trabeculæ) are all through made up of unstriped muscles. In the human spleen the capsule contains sparingly muscular bundles, and generally at those points only where the trabeculæ are inserted into the capsule. The larger trabeculæ, including the larger branches of the splenic artery and vein, contain in their periphery numerous bundles of unstriped muscles; the smaller trabeculæ also contain muscular bundles. I am surprised to find so many small trabeculæ containing slender bundles of muscles, as I did not expect to find this according to the assertions of previous authors.

With regard to the structure of the pulp I find that the matrix is of quite a different structure from what it is generally represented. First of all in well-prepared specimens I miss the reticulum of fine fibres mentioned by other observers; in pencilled as well as in unpencilled specimens I see a honeycomb of membranes, which only when seen in profile have the appearance of fibres. The pulp of the spleen of the dog shows this very distinctly (see fig. 1); here I find the general matrix represented by a honeycomb of membranes which when viewed from the surface possess the appearance of a transparent slightly granular film; the septa which are in connection with it and which extend in a plane vertical to the plane of the preparation give one the impression of being highly refractive fibrils (*c*). The membranes just mentioned include numerous nuclei which are chiefly of two kinds: (*a*) large pale round nuclei more or less flattened, and (*b*) smaller elliptical, spherical, or irregular-shaped nuclei; these stain much deeper in hæmatoxylin than the first named. In some places the membranous matrix, owing to more or less distinct markings, appears as if composed of polygonal, oblong, or irregular-shaped territories; to each territory corresponds one of the large pale nuclei; that is to say, in some places the membranous matrix appears to be composed of something very much like nucleated flattened cells—endothelial cells.

As has been mentioned before, the membranes form a honeycomb; the spaces ("cells") of this latter (honeycomb) are of very different sizes; at any rate they are merely discontinuities in the matrix and are therefore lined by no other tissue than the matrix itself; they form a labyrinth of anastomosing spaces. Many of them contain coloured blood-corpuscles either single or in twos or threes, the larger spaces contain also smaller or larger groups of yellowish-coloured lumps (evidently hæmoglobin-lumps). Here and there a nucleated bud of granular substance is seen to project into one or the other of the spaces; the bud is in intimate connection with the general matrix, both forming a continuity. Most of the smaller nuclei, mentioned above as belonging to the matrix, appear to be enclosed in such granular buds which are more or less projecting from the general matrix. These small nuclei correspond, according to all appearances, to the nuclei of the lymphoid or pulp-cells of the authors, and I am therefore inclined to think that they (pulp-cells) are in many places only nucleated buds of the general matrix, which (buds) probably become gradually separated so as to be lymphoid corpuscles, and are finally carried away by the blood-current. In support of this it may be mentioned that the number of the small nuclei and the nucleated elements which correspond to the lymphoid corpuscles is the smaller the more thoroughly the pulp had been previously washed and during the injection of the blood-vessels of the spleen. Besides, when describing the structure of the pulp of the human spleen we shall become acquainted with another important fact in support of the above theory.

What has been said until now of the structure of the pulp is consistent *only* with the theory that the venous radicles of the pulp are represented by a labyrinth of spaces in the matrix, advocated, as mentioned above, by Wilhelm Müller, Frey and others.

With reference to the stroma of the pulp of dogs I have to mention the presence of multinuclear masses belonging to, or forming a part of, it. Kölliker describes (l. c., p. 453) amongst the pulp-cells of young animals "finely-granular cells containing numerous (4 to 10 and more) nuclei, grouped together. . . . These peculiar multinuclear cells, which very much remind one of the multinuclear cells of the marrow of bones, and which he found in the blood of the liver of embryos, Kölliker believes to originate in the splenic pulp. The same observer found them also present in the blood of the splenic veins. The multinuclear cells show (l. c., p. 25) the peculiarity that their nuclei originate simultaneously by budding from one single nucleus.

These observations of Kölliker I am able not only to confirm, but I am also in a position to add to them the following: the multinuclear cells are only peculiar enlargements of the general matrix of the pulp, which, as we have seen, is a honeycomb of membranous structures. Thus also the multinuclear cells are flattened, branched structures in connection with the branched membranes of the stroma, as is accurately represented in figs. 1—4; they are of different sizes and are composed of the same pale transparent irregularly granular substance as the general matrix. The nuclei are seen to exhibit very active budding (see figs. 1—4). The smallest cells of this kind—*i.e.*, the youngest—possess a large nucleus which stains deeply in hæmatoxylin, and which shows several more or less deep constrictions and knobs (see fig. 4). The number of these latter increases in proportion to the size of the cell. Figs. 2 and 3 are very instructive examples. These flattened multinuclear enlargements of the general stroma are met with most frequently in the splenic pulp of young rats and half-grown dogs; they are less numerous in young dogs, and in man only rudiments of them can be found.

The examination of the pulp of the human spleen proved extremely successful with regard to the stroma, especially in the case of the enlarged spleen at the early stage of enteric fever, for here the latter is found to consist of beautiful flattened nucleated cells which form the elements of the honeycomb of membranes. (Compare figs. 2 and 3.) Into the smaller spaces of the honeycomb a nucleated knob is occasionally seen to project, being distinctly an outgrowth of the general matrix. From what has been said with respect to the dog's spleen it is only fair to conclude that also here these nucleated knobs represent the early stage in the development of the so-called lymphoid pulp-cells. The flattened cells of the matrix become at certain places so arranged as to form a continuous row of cells which, projecting on one surface freely into the cavity of a venous sinus, represent the endothelial wall of this latter. In fig. 4, which illustrates this point very well, A and B represent the wall of a venous sinus seen lengthways; the surface *a* is directed into the lumen of the vein. Also into these venous cavities nucleated knobs are found to project, and besides, some of the cells forming the wall of the sinus contain a constricted nucleus or even two nuclei; thus showing that there is a good deal of foundation for the assumption previously mentioned, viz., that nucleated knobs bud from the cellular stroma of the pulp, and become finally detached so as to form lymphoid corpuscles, which being carried away by the blood current represent colourless blood corpuscles. In very many cases the flattened cells of the stroma present a very peculiar appearance in the profile-view; this consists in one of their surfaces showing numerous small notches more or less regularly distributed. (Compare figs. 3 and 4.) I am not able to determine with certainty the meaning of this appearance; but it seems to me to be probably due to one surface of the cells being provided with linear thickenings. A similar appearance, but much more marked and in accordance with the explanation just given, is found in the wall of the venous sinuses of the splenic pulp of monkeys. In fig. 6 these venous sinuses (injected) are seen in transverse sections, their cellular wall seems to possess small rodlike structures which are evidently due to linear thickenings—as it were to ridges—running parallel to the longitudinal axis of the vein.

Thus it is seen that in the human spleen as well as in that of the dog the structure of the stroma of the pulp admits only of the theory of W. Müller, Frey, and others, *i.e.* that the venous radicles represent merely a labyrinth of spaces in the splenic parenchyma.

The question next to be considered is the relation of the matrix of the pulp to that of the adenoid tissue of the arterial sheaths and the Malpighian corpuscles. I am in accordance with those observers who maintain that the one passes gradually into the other. I have found very abundant evidence for this in the human spleen. Examining attentively the peripheral parts of the adenoid tissue, especially in preparations which have been previously shaken, it is found that the honeycomb of membranes of the pulp is directly continuous with the honeycomb of membranous structures forming the so-called reticulum of the adenoid tissue; with the difference, however, that in the latter the membranous structures become greatly reduced in their size and the meshes assume a more uniform aspect. The number of the nuclei of the matrix is at the same time reduced to such an extent that it becomes quite intelligible why Schweigger-Seidel ('Virchow's Archiv,' Bd. xxiii, p. 526) altogether questioned their existence in the reticulum of the adenoid tissue of the Malpighian corpuscles. As in the pulp so also in the adenoid tissue nucleated buds are found in more or less intimate connection with the matrix; in the adenoid tissue their number becomes very great, and they are in reality the well-known lymph corpuscles, many of which have become perfectly detached from the matrix.

In the pulp of the human spleen I find likewise lumps of yellowish pigment in smaller and larger groups, chiefly contained in the small spaces of the labyrinth and also in the matrix itself. Occasionally they are included in a cell. As was mentioned at the beginning of this paper, it is held that this pigment stands in an intimate relation to coloured blood-corpuscles, which having been taken up by lymphoid cells are broken up into small lumps within these structures. It seems to me more probable that the chief process of destruction of coloured blood corpuscles—*i.e.* the production of those yellowish lumps—is carried out not in the way generally described, *i. e.* blood corpuscles being taken up by lymph cells, but by the matrix itself exerting that destructive influence on the blood corpuscles. In support of this I adduce the constant presence of the free pigment lumps in the spaces of the labyrinth and in the matrix of the spleen of dog; I have seen only extremely few distinct instances in the spleen of this animal, where these lumps were contained in a lymphoid cell. And also with regard to the normal human spleen, the lymphoid cells including coloured blood-corpuscles are relatively very rare; they are by no means so frequent as is generally represented.

A Differential Warm Stage. By C. H. Golding-Bird, B.A., M.B., F.R.C.S.E., Assistant-Surgeon, Guy's Hospital, and Hon. Sec. Med. Mic. Society.

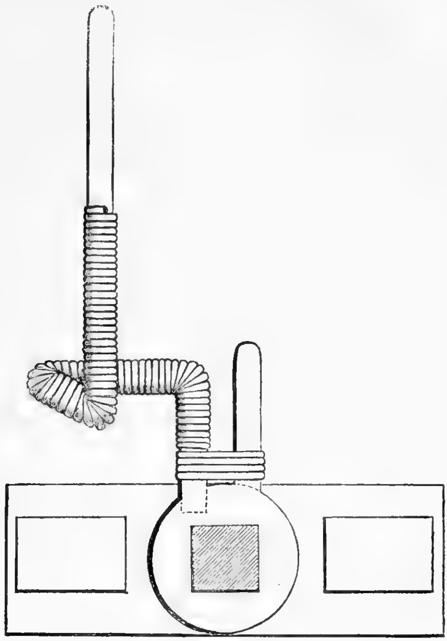
The following is the description of a warm stage that appears to possess certain advantages over the simple copper one often employed, and to possess certain of those which belong to the more complicated arrangements where the heat is maintained by a constant stream of hot water.

By it a fairly uniform temperature may be kept up for a long time, while any variation of sufficient importance to affect the specimen under examination may be at once observed and speedily corrected by simply moving the lamp by which the instrument is heated, and this is only necessary at long intervals as a rule. There is a great source of fallacy in the simple copper stage, where the heat is applied to a projecting copper wire, and in which cacao butter, placed on the metallic ring that is cemented to the glass slide, is used as the index of the temperature; for while the melting of the cacao butter points to the copper ring having reached the temperature of the human body, it by no means follows that the centre of the small glass cover which is placed upon it, and which bears the specimen, is heated to the same degree. Experiment proves this to be the case, a much higher temperature than that of 98° F. being required for the stage before the glass cover upon it has actually reached the temperature of the blood, while the sudden fluctuations of the temperature are very frequent, and no longer to be registered when the cacao butter has once melted.

The combination of two metals and the use of pieces of solid paraffin, placed at proper intervals, seem to overcome these difficulties.[1] The instrument consists of a disc of copper, of the size and thickness of a halfpenny, in the centre of which a hole, three eighths of an inch across, is cut, while let into it on one edge (as shown in the accompanying woodcut), and firmly soldered, is an iron wire one tenth inch in diameter,

[1] The stage is made by Millikin, of St. Thomas's Street, Southwark.

and five inches long. To the same edge is soldered also a tongue of copper—in the position shown—an inch long, and a quarter of an inch in breadth. A piece of crdinary copper



bell-wire is now wound round both the copper tongue and iron wire for four turns, commencing close to the disc, after which the wire is carried on up the iron wire only, covering it for three and a quarter inches, reckoning from its attachment to the disc; both the four large turns and the smaller subsequent coil should be closely wound, a little separation, of about the thickness of one coil, being allowed between the last of the large and the first of the small turns. This prevents the heat being too rapidly conveyed to the stage. The disc is now fastened with sealing-wax to a glass slide, the wire projecting beyond, while in the places where the labels are usually placed should be gummed slips of cardboard on both surfaces, so as to prevent the immediate contact of any part of the instrument with the stage of the microscope.

It does not matter how the iron wire is bent; that here shown is the most convenient form for use with such a microscope as Verick's. The next step is to graduate the warm stage thus constructed, and this once carefully done—and a note of it can be conveniently made upon the cardboard that occupies the place of the labels—the instrument can on any future occasion be raised to the required temperature in a few minutes. To graduate it place upon the copper disc a glass cover (five eighths or three quarters of an inch square), care being taken that it does not touch the coils of copper wire, and on the centre of the cover a small piece of cacao butter. The copper tongue, the large coils of copper wire, and the first two small coils, should each have upon them a small fragment of solid paraffin, the melting point of which is much higher than that of cacao butter, and the top of the flame of a spirit lamp should play upon the iron wire just beyond the copper coils, or may, according to circumstances, include the first two or three. In the instrument from which this description is taken it is found that when this is done, and the stage warmed sufficiently to allow the cacao butter just to dissolve, that the paraffin on the small coils has completely melted, that on the large coils is just sticky, and that on the copper tongue unaffected. The spirit-lamp may now be moved a little further off if it be thought necessary, the guide being if the paraffin on the large coils shows a disposition to melt, all that is now required being to ensure sufficient heat being conveyed along the combined copper and iron wires to make up for that lost by the stage from conduction or radiation. Where only copper wire is used it is hard to prevent the heat rising too rapidly, and where iron alone it is difficult to prevent the reverse; but where the two are combined, and the flame applied to the iron, the copper seems to make up that deficiency in conduction in the iron that renders it unfit to be used alone. It is, of course, evident that each instrument must be tested, for though the positions and conditions of the paraffin given have been noted from a warm stage, constructed as here described, yet variations will be met with according as the coils are more or less closely wound. The way in which the cacoa butter melts should be observed also; if a second piece be dropped upon the glass cover, and melt *immediately*, the stage has been overheated; but if it *gradually* and *deliberately* subside in the course of a few seconds the required temperature may be fairly assumed to have been obtained. The longest time during which the same white blood-corpuscle was watched on this stage was an hour and an half. The spirit-lamp was moved but once, and that because the middle piece of paraffin showed signs of liquefying, while at the end of that time there seemed to be no reason why the same observation should not, as far as the stage was concerned, be carried on indefinitely. It was used on this occasion for the purposes of demonstration to others, while the whole attention could thus be directed to the specimen, a casual glance being cast at the pieces of paraffin from time to time. As far as possible draughts of air should be avoided, as they tend both to cool the stage and blow the flame, so that the temperature may rise rapidly to an undesirable degree.

To prevent evaporation of the fluid under observation it is usual to smear the edges of the cover-glass on which the specimen is placed, and which should be rather smaller than that lying on the copper disc, with oil, but cacao butter may for this claim the preference. The second cover-glass, on the under surface of which is smeared the blood to be examined, is touched round its edge with solid cacao butter. It is now lightly dropped upon the glass that has been already raised to the required temperature on the stage. The solid cacao butter prevents the first shock, by its projection from the under surface of the glass, and the consequent scattering of the fluid and the formation of air-bubbles are prevented, while the moment that it melts it runs evenly and uniformly round, hermetically closing the space between the two glasses.

If the instrument be well warmed before being fixed to the stage of the microscope it will be more quickly put into action; and in cold weather especially it is advisable to do so, as the temperature of the surrounding air makes a marked difference in the time required for raising the stage to the required heat.

The woodcut represents the hole in the disc as square, but it is more easily made circular, and perhaps more effective, as the heat can then approach the centre of the glass cover, where the specimen lies, equally from all directions.

A Double Staining *with* Hæmatoxylin *and* Aniline.

By W. H. Poole, B.A. Oxford, Science Master at Friars' School, Bangor.

When engaged last autumn in the Anatomical Department of the Oxford University Museum in making microscopic preparations of brain, my attention was especially directed to the staining of the sections.

My first attempts were made with hæmatoxylin and carmine. Of these the latter proved useful for detecting nuclei, but, the protoplasm of the cells remaining almost uncoloured, it was impossible to distinguish the shape of the different cells, a matter of the greatest importance where, as in the brain, cells are met with of such various shapes and sizes. Another great deficiency in the carmine-stained sections was the indistinctness of the fibres. In all cases a long time was required for the carmine to take any effect, sixty to seventy hours being insufficient to stain deeply.

Hæmatoxylin produced much more successful results. In the first place, the fibres were almost always brought out distinctly; and secondly, the cells with their processes were in many cases clearly defined. But still the cortical substance was frequently insufficiently stained even after twenty-four hours' immersion in the staining fluid, which, owing to the use of alum, is sufficient to render the preparations too brittle to be easily mounted. The special value of hæmatoxylin consists in the clearness with which it brings out the nuclei of the medullary substance and the fibres and cell-processes of the cortical substance; its fault is a want of depth in the colour of the cortical substance.

Having found aniline-blue useful for staining some hardened tissues, I was led to try it in this case. The only virtue it had was that it stained the protoplasm of the medullary cells very darkly and always attacked them first; that is to say, its strongest point exactly agreed with the weakest point in hæmatoxylin.

This led me to try double staining, and the results were fully up to my expectations. The following is the method of staining which I finally adopted. After from twenty to twenty-four hours' immersion in hæmatoxylin I washed the preparation in weak spirit, and then in distilled water till all the spirit was driven out. I then immersed it in aniline for from half to three quarters of a minute; again washed it in spirit, and after the usual treatment mounted it in Dammar.

The preparation of hæmatoxylin used was that recommended by Frey, *i.e.*, a few drops of an alcoholic solution of the pure crystals added to a solution of alum in water. The latter I have used in the proportion of from 2·4 grains of alum to an ounce of water. The more alum there is in the solution the more rapid is the staining, but there is great danger of making a thin section too brittle by the use of much alum. The aniline I diluted sufficiently to be able to see through it pretty easily.

The results obtained by this method are most satisfactory.

The nuclei already stained by the hæmatoxylin are made of a richer colour, while the protoplasm surrounding them is much bluer than the nuclei themselves. In the cerebellum the effect is particularly good, the medullary substance being of a rich purple, and the cortical substance of a pale blue, but showing the cells with remarkable clearness.

Some Remarks *on* Spinal Ganglia *and* Nerve-Fibres.

By Jeremiah McCarthy, F.R.C.S. Eng., Lecturer on Physiology at the London Hospital Medical College. (With Plate XXII.)

I have recently, in examining preparations of spinal ganglia, observed some structural details which were new to me, and to which I wished to direct attention. But, on consulting the abundant literature on the subject, I find that nearly all the points have been anticipated by other observers. Still, as the mode of preparation which I have used brings out these structural details very clearly, and as my investigations were made in ignorance of the recent discoveries, my independent corroboration of them may not be uninteresting to readers of this Journal.

I have used as material the spinal ganglia of dogs, and prepared them in the following manner:—The animal having been killed, the ganglia were at once taken out and kept in 2 per cent. solution of mono-chromate of ammonia for three weeks, and, the solution having been changed once or twice during that time, were then transferred to methylated spirit. After a few days longer they were ready for section. The sections were stained with hæmatoxylin, and were finally mounted in Canada balsam solution. Sections so prepared form very beautiful microscopic objects, as there is no shrinking or disturbance of the relation of the tissues.

The surface of the ganglion is covered by a thick layer of fibrous tissue, which contains numerous blood-vessels and a little fat. From this processes pass into the ganglion, and, there ramifying, form a delicate meshwork for the nerve-fibres or blend with the capsules of the ganglion-cells. The ganglion-cells are very unequal in size, the largest being five or six times the size of the smallest, and between these extremes are numerous gradations.[1] These cells are arranged

[1] With Hartnack's No. 2 micrometer ocular, and No. 8 objective, some of the largest cells measure 0·080 m. in diameter, some of the smallest, 0·014 m.

in clusters and sometimes in spindle-shaped groups, the long axis of which corresponds to the long axis of the ganglion. Occasionally a solitary ganglion-cell may be seen, but this does not appear to be interposed in the course of a nerve-fibre, as some writers describe, but rather to result from the section having passed through a terminal cell of one of these spindle-shaped groups. Each cell is bounded by a very sharply defined border, in which nuclei of connective-tissue corpuscles may be distinguished. Within this is a broad band of apparently hyaline substance with nuclei imbedded in it. This hyaline layer is broadest where a nucleus is situated, in parts where there are no nuclei becoming about one third narrower. Examined with a No. 11 immersion Hartnack, it appears faintly fibrillated. The nuclei are mostly round, but some are oval, and in each of them a nucleolus and some granules may be seen. With hæmatoxylin they assume a pale violet colour, thus presenting a marked contrast to the nuclei of the outermost layer of the capsule, which take a much deeper tint. The number and arrangement of these nuclei are variable. In some capsules there are only three or four such nuclei, in others of equal size, eighteen or twenty. Again, they are sometimes isolated, sometimes in pairs, either overlapping or barely separate, and sometimes in groups of seven or eight; this last arrangement being most frequently seen at the junction of a nerve with a ganglion-cell, where the section admits of such continuity being traced. This hyaline layer, in most cells, has no definite limit internally, but shades off into a cloudy substance, which in turn is continuous with a molecular mass, in which is imbedded a very large nucleus. This molecular mass is not the same throughout. Internally it often appears faintly fibrillated, concentrically with regard to the nucleus, while externally it has a more granular appearance, these granules also being concentrically arranged, and is of a darker colour. This outer part very usually contains a large irregular group of pigment-granules. The nucleus has a very definite membrane, and is composed of some very finely granular matter with a few larger granules and a nucleolus. On careful examination some differences may be detected in the nuclei of different cells. In some of the smallest ganglion cells the nuclei have a more compact appearance, and stain of a pale violet colour, so as, but for their larger size and sharply defined borders, to very much resemble the nuclei of the hyaline layer. In some of the larger cells the nuclei, on the contrary, have an almost vesicular appearance, are quite colourless, and the nucleoli are unstained, shrivelled, and like pigment-granules. Between these extremes numerous gradations can be seen, but it must be stated that the condition of the nucleus does not seem to depend upon the size of the cell, as colourless vesicular-looking nuclei may be found in some of the smallest cells. In cells where the nuclei become stained the surrounding substance appears more homogeneous, and also assumes a pale violet tint. In no instance have I ever seen more than one nucleus in a ganglion-cell.

The differences in the appearance of the nuclei suggest the conjecture that ganglion-cells may be regenerated from this nucleated hyaline substance. This conjecture is supported in some degree by the position of the smaller cells, which often seem as if they had been buds growing from the larger cells with which they are in contact. It is further supported by some observations of Mayer, quoted in Canstatt's 'Jahresbericht' for 1874, p. 45, who states, as the result of examination of frogs, toads, and tritons, that the so-called nuclei of Schwann's sheath of peripheral nerves are originally large nucleated cells lying upon the inner surface of the sheath, and that as they participate in the regeneration process of the nerve they probably belong to the nerve-tissue. As I have been unable to obtain the original paper, I do not know on what ground Meyer assumes that these cells are concerned in the regeneration of the nerve; but if his assumption be correct it would apply equally well to the nucleated interior of the ganglion-cell capsule, which is analogous to the cells described by him on the interior of Schwann's sheath.

The existence of nucleated cells on the interior of the capsule of ganglion cells has long been known. Remak, quoted by Schwalbe in Max Schultze's 'Archiv' for 1868, p. 58, describes these capsules as composed of a soft cell-layer and of a firm membrane; Wagner and Robin, quoted by Fraentzel in Virchow's 'Archiv' for 1867, p. 557; Valentin, in Müller's 'Archiv,' 1839, p. 139; Henle, in his 'General Anatomy;' and Kölliker, in his 'Gewebelehre,' 1867, p. 250, describe and figure such cells; but the illustrations poorly represent what the appearance is as seen in preparations made in the manner above described. Fraentzel (loc. cit.) has by nitrate of silver demonstrated that this layer is composed of epithelial (? endothelial) plates, and in this he is corroborated by Schwalbe (loc. cit.) and Arndt (Max Schultze's 'Archiv,' 1874, p. 140). The difference as to the number of nuclei in the corpuscles of different cells has been noticed by both Schwalbe and Arndt. The latter regards the greater number of nuclei as the result of the persistence of an embryonal condition, and that where there are few nuclei the embryonal cells have become transformed into connective tissue of a fibrillar character. To me, on the contrary, it appears more probable that the larger number of nuclei are the result of proliferation of previous nuclei. See figs. I and II.

The nerve-fibres run in a very irregular manner through the ganglion, so that a section of the ganglion shows the fibres cut, some transversely, some obliquely, and some longitudinally. Ranvier's constrictions in the sheath of Schwann can be very distinctly seen, and the nuclei often appear more within than in this sheath (cf. Mayer's observations). The medullary sheath appears to be composed of small rods radiating from the axis cylinder to the sheath of Schwann. The arrangement of these rods, as seen in transversely cut nerve-fibres, is not always the same. In some the entire space between the axis cylinder and the sheath of Schwann is occupied by these rods, while in others the rods appear shortened, and also compressed laterally into bundles imbedded in some homogeneous substance. Again, in longitudinal sections, the appearance varies according to the place of section. If the section has passed exactly through the centre of the fibre these rods appear in a regular line and at right angles to the axis cylinder; but if the section has not passed through the centre, then these rods, being cut at various angles, produce a cloudy or stippled appearance.

Reference to the accompanying illustrations, for the very beautiful and accurate drawing of which I am indebted to the kindness of Dr. Klein, will enable the reader to better understand my description.

The regularity of the arrangement of these rods, as seen in some longitudinal sections of nerve-fibres, is very suggestive of the appearance of striated muscle. In the Sydenham translation of Stricker's 'Histology,' vol. i, p. 161, Dr. Grandry is said to have observed in *naked* axis cylinders, as well as in those enclosed in a medullary sheath after treatment with nitrate of silver, fine transverse striations of such regularity as to remind the observer of the structure of striated muscle. If this description be correct, it cannot refer to the structure which I describe, which is most unquestionably in the medullary sheath. Lautermann ('Centralbl., f. d. Med. Wissensch.,' No. xlv, p. 706, 1874) is inclined to agree with Stilling in regarding the medullary sheath as composed of small tubules, and then makes very brief allusion to rod-like bodies, such as I describe, seen by him in osmic acid preparations. Reference to the descriptions and illustrations in Stilling's elaborate work ('Untersuchungen ü. d. feineren Bau. d. Nervenprimitivfaser,'&c.,1856) will, I think, convince the reader that there cannot be any possibility of confounding these rod-like bodies with the interwoven and anastomosing tubules described by Stilling. He makes numerous quotations, proving that Fontana, Valentin, Ehrenberg, Kölliker, and many others have remarked in the coagulated medulla irregular masses, which with various reagents showed rods either single or united in a retiform manner; but in no publication have I been able to find anything corresponding to what I have described and figured as the arrangement of these structures.

It may be objected that this striation is artificial and the result of the reagents employed. To this I would reply (1) that the great regularity of the appearance is opposed to this; (2) that Heidenhain, who was the first to employ monochromate of ammonia, discovered the very similar condition of the protoplasm of the epithelium of the convoluted portion of the renal tubules, so that if the striation be artificial in the one case, it must be artificial in the other case also; and (3) the fibrillation of the mass of the ganglion-cells seen in these preparations has hitherto been observed chiefly in fresh ganglion-cells treated with iodized serum; so that the preservation of this, which seems to be the natural unaltered state of the ganglion-cell, would be a strong presumption in favour of the described striation also being non-artificial. I am still, however, investigating the matter, and publish this in order to direct the attention of histologists to the point in question, and to the advantages of this mode of preparing spinal ganglia.

NOTE *on a* PINK-COLOURED SPIRILLUM (*Spirillum rosaceum*). By DR. E. KLEIN, F.R.S.

ON the 26th December of last year Dr. Mackellar, of the Fever Hospital at Stockwell, placed for me a small quantity —about half a drachm—of fresh fæcal matter, obtained from a recent case of enteric fever, in a bottle containing about four ounces of water. The sediment, which was of a yellowish-white colour, contained, when examined under the microscope, very numerous, bright, highly refractive, large (spherical) Micrococci, either isolated or in dumb-bells, or forming smaller or larger masses of Zooglœa.

On the 30th of the same month, in addition, a few briskly moving individuals of *Bacterium termo* were to be seen, and very numerous, bright, highly refractive, non-moving, rod-like structures, which appeared to be offsprings of the (spherical) Micrococci.

In April of this year I first noticed that the sediment became covered with a thin film of a rosy tint. While the intensity of the colour of the latter went on increasing, the sides of the sediment, *i. e.* the surface touching the glass, also assumed that colour, the intensity, however, decreasing towards the depth.

At present (middle of July) the sides of the sediment possess a distinct rosy hue, whereas the film covering its (sediment) free surface, *i. e.* that which is in free contact with the fluid, is of a deep pink colour. The interior of the sediment has retained its original colour.

The film is composed entirely of masses of spirillum, chiefly forming Zooglœa, between which numerous isolated examples are seen. The Zooglœa consists chiefly of what is termed by Cohn ('Beiträge zur Biologie der Pflanzen, Untersuchungen über Bacterien,' p. 181) *Spirillum undula.* Amongst the isolated examples, some of which present only occasionally active movement, I find numerous *Spirillum tenue,* and also some whose size gives them a close resemblance to what the same author describes and figures (see his fig. 21) as *Spirillum volutans;* in our case the last named are, however, in a resting condition. Also a few examples of *Spirichæte plicatilis* (see Cohn's fig. 22) are to be met with.

I have found ample evidence to maintain that the *Spirillum tenue* is identical with the Spirichæte, from which it differs only with regard to length, for I have seen all possible intermediate forms between the two—*Spirillum tenue* of four to six turns, of six to eight turns, such of twelve turns and lastly of more than twelve; those that exceeded eight or ten turns were folded so as to resemble completely Cohn's *Spirichæte plicatilis.* Occasionally pairs of Spirillum may be seen so arranged as to resemble a Mercury's staff.

The Zooglœa-masses are made up, as already mentioned, of *Spirillum undula.* The interstitial substance, in which the latter are embedded, is perfectly colourless, whereas the Spirilla present a rosy coloration, which is more distinct in proportion to the thickness and density of the layer formed by them. In the isolated examples and in small groups of them the colour is hardly perceptible.

What has been said with regard to the film on the surface of the sediment is true also for the sides of this latter, their lighter colour being due merely to the Spirilla not being abundant enough to cover altogether the fatty residues of the original fæcal matter.

As far as I know Spirillum has not been noticed hitherto to form coloured masses. Cohn, in his well-known paper, mentions only (spherical or elliptical) Micrococcus amongst the chromogenous Bacteria (*Micrococcus prodigiosus* and *M. luteus* forming pigment insoluble in water; *M. aurantiacus, M. chlorinus, M. cyaneus*, and *M. violaceus*, forming pigment soluble in water). E. Ray Lankester describes ('Quart. Journ. Mic. Science,' vol. xiii, new ser., p. 409) a peach-coloured Bacterium (*Bacterium rubescens*), which forms pigment insoluble in water. Burdon Sanderson mentions (in Lectures on Specific Contagia, delivered at Owen's College, Manchester; see 'British Medical Journal,' March, 1875) a blue Bacterium (insoluble).

I have seen myself a purplish-blue *Bacterium Termo* (pigment insoluble in water) grow on flour-paste that had been given to me by Dr. Mackellar, of the Fever Hospital at Stockwell.[1]

As has been mentioned above, the pigment is, in the present instance, contained in the Spirilla themselves, and is accordingly not soluble in water. It is likewise insoluble in alcohol, but becomes, however, destroyed when left in it. It is insoluble in cold as well as in boiling chloroform; the latter destroys the colour. Mr. F. J. M. Page, to whom I am indebted for the spectroscopic analysis, finds that it becomes more transparent when treated with a drop of weak caustic potash (40 per cent.), without, however, forming a clear solution; and this solution, which is distinctly rose-coloured when examined with a small Browning's spectroscope, shows an absorption-band close to the D line, and a suspicion of a second band in green, the red being at the same time shortened.

The quantity at my disposal precluded a more detailed examination.[2]

[1] Virchow ('Gesammelte Abhandlungen zur Wissenschaftl. Medizin,' p. 144) mentions several instances in which a rosy colour has been observed in putrid albuminates (casein) after the addition of mineral acids. Virchow himself noticed a rosy coloration of the rice-water stools in cholera after adding nitric acid. (The stools contained vibrio and ciliated monads).

I need hardly say that all this is entirely different from the rosy coloration in our case.

[2] With a view to obtain a greater quantity of *Spirillum rosaceum*, I inoculated with it several cubic centim. of Cohn's nourishing fluid for bacteria, having added to this fluid previously 1 per cent. of acetate of ammonia. The inoculated material was placed in the incubator and kept there at a

On the Structure *of the* Proboscis *of Ophideres fullonica, an* Orange-sucking Moth. By Francis Darwin, M.B.

It must be premised that the fact of some Lepidoptera piercing vegetable tissues for the purpose of obtaining the juices is not a new one. In his 'Fertilisation of Orchids' my father shows that the lining membrane of the nectaries of certain orchids are bored through in this way. Moreover, Mr. R. Trimen informed my father that, at the Cape of Good Hope, a great deal of fruit is thus injured by Lepidoptera.[1]

I owe the material on which the following observations were made to the kindness of Mons. Anthelm Thozet, of Rockhampton, Queensland. A few dried specimens of *Ophideres fullonica* were sent by him to my father, together with his interesting account, published in a Queensland paper, of the injuries caused by the moth to the oranges in that part of Australia.

The antlia or proboscis of Lepidopterous insects is well known to be composed of the transformed maxillæ; each of these is channelled along its internal face, and the two demi-canals fit closely together, and form a complete channel or tube traversing the proboscis from end to end. Fig. 3 is a transverse section of the proboscis, *ch* being the channel, *tr* the large trachea, which run one in each half of the organ. The intrinsic muscles of the maxillæ which surround the tracheæ are here omitted.

The proboscis, of which only the distal portion is represented in Figs. 1 and 2, measured ·72 inch in length; the wings of the moth to which it belonged were too much broken for measurement, but a larger specimen gave a width of four inches from tip to tip of the extended wings, and had a proboscis ·74 inch in length.

The convex border of Fig. 1 represents in profile, the outline of the dorsal aspect of the proboscis; the concave border gives that of the ventral aspect. The saw-like or cutting portion of the proboscis—(*i. e.* from its tip to the barbs (*b*,

constant temperature of about 38·5° C. After three days the rosy coloration had entirely disappeared and the fluid remained colourless also afterwards, although an abundant floccular sediment has made its appearance.

[1] Since making the observation here recorded, I have seen a note on the structure of the proboscis of *Ophideres fullonica* by M. Künckel ('Comptes Rendus,' Aug. 30, 1875). It contains excellent drawings of the organ, together with a short description of it.

Figs. 1 and 2)—is roughly triangular in transverse section, *i. e.* bayonet-shaped. Of the three surfaces of the bayonet

Fig. 1.

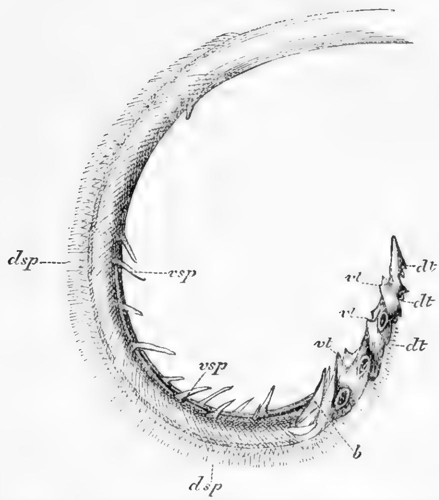


Fig. 1.—Proboscis of *Ophideres fullonica* drawn lying on one side.
vt vt. Ventral teeth.
dt dt. Dorsal teeth.
lt. Lateral teeth.
b. Lateral barbs.
dsp. Dorsal spines forming a frill along nearly one half of the length of the organ.
vsp. Ventral spines.

one forms the dorsal aspect of the proboscis and supports the frill of dorsal spines (*d, sp*, Fig. 1); the other two surfaces are symmetrical with each other, and may be called ventral-lateral surfaces, since they form the *sides* of the organ as seen in Fig. 1, and, by meeting along the edge (*g* in Fig. 2), they form its ventral aspect. The line (*g*) just mentioned is continuous with a narrow groove running along the ventral aspect of the proboscis (*g*, Figs. 2 and 3); at the distal extremity of the line (*g*) is seen the orifice (*o*), by which the channel traversing the proboscis opens externally on the ventral aspect, thus resembling the canula of a subcutaneous syringe.

It is clear that in using its proboscis the insect must employ a thrusting action, and not any kind of revolving movement; the proboscis must accordingly be considered as a saw, not as an augur or gimlet. It is, in fact, a bayonet-shaped saw, and must, therefore, have three cutting edges.

Along the *concave* border, in Fig. 1 (the ventral aspect) may be seen four pairs of teeth (*vt, vt*, &c.), making in all eight projecting points; these unite in forming one of the cutting edges of the saw. We obtain a bird's-eye view of this same edge in Fig. 2, where the symmetrical teeth (*vt, vt*) may

FIG. 2.

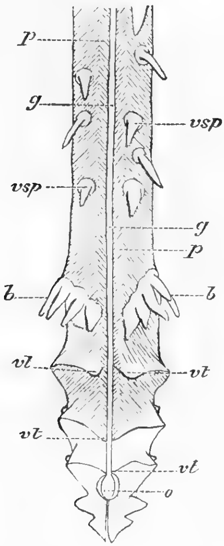


FIG. 2.—Bird's-eye view of the ventral aspect of the proboscis.

vt vt. Ventral teeth meeting in pairs on either side of the median line (*g*).

g. Narrow groove occupying the angle of the roof-like ridge of which the ventral aspect consists. The roof is supposed to rise towards the observer, *g* being merely a crack running along the roof-tree.

b. Barbs.

o. The orifice or external opening of the channel or tube of the proboscis.

p. See text.

be seen meeting each other in pairs along the line (*g*). The two other cutting edges of the bayonet-saw are formed by teeth projecting from the dorsal margins of the two lateral surfaces. One of these cutting edges is seen in profile in Fig. 1 (*dt, dt*). If we imagine a saw with a broad back, having a cutting edge along each margin of the *back*, as well as along the proper cutting edge, it will resemble the bayonet-shaped proboscis-tip.

It will be seen that the teeth on the ventral edge of the saw point towards the tip, those forming the two dorsal edges pointing in the opposite direction. Therefore, as the saw is thrust into the orange, the ventral teeth will begin to cut; as it is withdrawn the dorsal ones will take up the work. If a man were to work with a saw, which besides the usual teeth possessed others on its back pointing in the reverse direction, and if he were, besides sawing in the usual way, to cut another piece of wood at each back stroke with the *upper* edge, he would have to press first with the lower edge of his tool and then with the upper one. This alternation of pressure is effected in the saw of Ophideres in a curious manner. In Fig. 1 three strong ridges with corresponding depressions may be seen running obliquely across the side of the proboscis, each being continuous with one of the projecting ventral teeth; in this drawing they are necessarily represented by light and shade, but in Fig. 2 they are seen in profile. It is clear that the effect of the obliquity of these ridges will be to make the ventral teeth "bite" as the saw *enters* the fruit, and that the moment it begins to be withdrawn the pressure will be taken off the ventral teeth and transferred to the dorsal ones, which are thus in their turn forced up against the part of the wound on which they have to work. Moreover these ridges, assisted by the barbs (*b*, Figs. 1 and 2), convert each lateral surface of the saw into a rasp; the curious peg-like teeth (*l t*), of which there are three on each lateral surface, aid in the same object. Whether the frill of delicate spines (*dsp*, Fig. 1) on the dorsal aspect assist in the rasping or sawing action I cannot determine, nor what the special function of the stronger spines in the ventral surface (*vsp*) may be.

Mr. A. G. Butler has been so good as to inform me that *Catocala nupta* would be a fair representative of the nearest British allies of Ophideres. In accordance with its simple nectar-sucking functions, the proboscis of Catocala is very different in structure to that of Ophideres.[1] It ends in a blunt tip, and has none of the saw-like teeth and ridges described in Ophideres; it is covered on its dorsal aspect with a number of curved spinous hairs and with blunt papillæ like those figured by Newport ('Cyc. of Anat. and Phys.,' vol. ii, p. 900) on the proboscis of *Vanessa*

[1] Mr. Butler says that "the Catocalidæ differ much in the form of the palpi from the Ophideridæ;" so that some difference might be expected in the structure of the proboscis.

atalanta. The chitinous parts forming the channel and the rest of the proboscis are very much stronger in Ophideres than in Catocala, and the muscles which serve to extend the proboscis and make it into a stiff rod are more developed. The proboscis of Ophideres is apparently unable to roll up into the *close* helix which we find in Catocala and most Lepidoptera. Each half of a Lepidopterous proboscis is said (Newport, loc. cit.) to be made up of a number of superimposed rings, and in the proboscis of Catocala five transverse lines are seen marking out these rings. In Ophideres, however, these file-like markings are oblique instead of directly transverse, and at a point (*p*, Fig. 2) they are abruptly bent at an acute angle, making a beautiful series of V's on each side of the line (*g*); the point (*p*) is shown also in the section (Fig. 3). The oblique rings give a curious imbricated appearance to the periphery of each half of the proboscis.

Fig. 3.

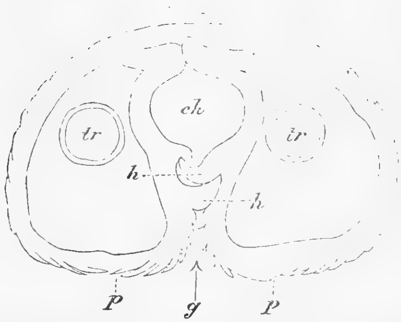


Fig. 3.—Transverse section of the proboscis (not the sawing part. Semi-diagrammatic).
ch. The channel or tube of the proboscis.
tr tr. The large trachea running down each half of the organ.
h h. Locking apparatus, keeping the two halves in contact.
g. Groove running down ventral surface of proboscis.
dsp. Shows the position of the dorsal frill of spines; these are so delicate that nearly all are broken in making sections.
m. The space filled up by muscle which is here omitted.
p. Corresponds to *p* in Fig. 2. See text.

Finally, the apparatus which locks the two halves of the organ together is very remarkable. Fig. 3 is a section of the proboscis showing the strong curved teeth (*h*, *h*) which, by closely hooking into one another, must effectually prevent dislocation; the delicate spines (*dsp*) on the dorsal surface may perhaps contribute to the same result. Neither

Newport nor Kirby and Spencer give clear descriptions or figures of any such locking mechanism, and in Catocala it is very slightly developed. It is remarkable that, owing to the development of the processes (*h h*), the proboscis ceases to be, strictly speaking, a bilaterally symmetrical organ.

NOTES AND MEMORANDA.

Professor Huxley on the Genus Bathybius.—The following extracts from a latter dated Yeddo, June 9th, 1875, addressed to me by Professor Wyville Thomson, will, I think, interest the readers of 'Nature':—

"In a note lately published in the proceedings of the Royal Society on the nature of our soundings in the Southern Sea, I stated that up to that time we had never seen any trace of the pseudopodia of Globigerina. I have now to tell a different tale, for we have seen them very many times, and their condition and the entire appearance and behaviour of the sarcode are, in a high degree, characteristic and peculiar. When the living Globigerina is examined under very favorable circumstances, that is to say, when it can at once be transferred from the tow-net and placed under a tolerably high power in fresh, still sea-water, the sarcodic contents of the chambers may be seen to exude gradually through the pores of the shell and spread out until they form a gelatinous fringe or border round the shell, filling up the spaces among the roots of the spines, and rising up a little way along their length. This external coating of sarcode is rendered very visible by the oil-globules, which are oval and of considerable size, and filled with intensely coloured secondary globules; they are drawn along by the sarcode, and may be observed, with a little care, following its spreading or contracting movements. At the same time an infinitely delicate sheath of sarcode containing minute transparent granules, but no oil-globules, rises on each of the spines to its extremity, and may be seen creeping up one side and down the other of the spine, with the peculiar flowing movement with which we are so familiar in the pseudopodia of Gromia and of the Radiolarians. If the cell in which the Globigerina is floating receive a sudden shock, or if a drop of some irritating liquid be added to the water, the whole mass of protoplasm retreats into the shell with great rapidity, drawing the oil-globules along with it, and the outline of the surface of the shell and of the hair-like spines is left as sharp as before the exodus of the sarcode. We are getting sketches carefully prepared of the details of this process, and either Mr. Murray or I will shortly describe it more in full. . . .

"Our soundings in the Atlantic certainly gave us the impression that the siliceous bodies, including the spicules of Sponges, the spicules and tests of Radiolarians, and the Frustules of Diatoms which occur in appreciable proportions in Globigerina ooze diminish in number, and that the more delicate of them disappear, in the transition from the calcareous ooze to the 'red clay;' and it is only by this light of later observations that we are now aware that this is by no means necessarily the case. On the 23rd of March, 1875, in the Pacific, in lat. 11° 24′ N., long. 143° 16′ E., between the Carolines and the Ladrones, we sounded in 4574 fathoms. The bottom was what might naturally have been marked on the chart 'red clay;' it was a fine deposit, reddish brown in colour, and it contained scarcely a trace of lime. It was different, however, from the ordinary 'red clay'—more gritty—and the lower part of the contents of the sounding-tube seemed to have been compacted into a somewhat coherent cake, as if already a stage towards hardening into stone. When placed under the microscope it was found to contain so large a proportion of the tests of Radiolarians, that Murray proposes for it the name 'Radiolarian ooze.' This observation led to the reconsideration of the deposits from the deepest soundings, and Murray thinks that he has every reason to believe (and in this I entirely agree with him) that, shortly after the 'red clay' has assumed its most characteristic form, by the removal of the calcareous matter of the shells of the Foraminifera, at a depth of say 3000 fathoms, the deposit begins gradually to alter again by the increasing proportion of the tests of Radiolarians, until, at such extreme depths as that of the sounding of the 23rd of March, it has once more assumed the character of an almost purely organic formation, the shells of which it is mainly composed, being, however, in this case, siliceous, while in the former they were calcareous. The 'Radiolarian ooze,' although consisting chiefly of the tests of Radiolarians, contains, even in its present condition, a very considerable proportion of red clay. I believe that the explanation of this change, which was suggested by Murray, and was indeed almost a necessary sequence to his investigations, is the true one. We have every reason to believe, from a series of observations, as yet very incomplete, which have been made with the tow-net at different depths, that Radiolarians exist at all depths in the water of the ocean, while Foraminifera are confined to a comparatively superficial belt. At the surface and a little below it the tow-net yields certain species; when sunk to greater depths, additional species are constantly found, and, in the deposits at the bottom, new forms occur, which are met with neither at the surface nor at intermediate depths. It would seem also that the species increase in number, and that the individuals are of larger size as the depth becomes greater; but many more observations are required before this can be stated with certainty. Now, if the belt of Foraminifera which, by their decomposition, according to our view, yield the 'red clay,' be restricted and constant in thickness, and if the Radiolaria live from the surface to the bottom, it is clear that, if the depth be enormously increased, the accumulation of the Radiolarian tests must gain upon that of the 'red clay,' and finally swamp and mask it."

Professor Wyville Thomson further informs me that the best efforts of the "Challenger's" staff have failed to discover *Bathybius* in a fresh state, and that it is seriously suspected that the thing to which I gave that name is little more than sulphate of lime, precipitated in a flocculent state from the sea-water by the strong alcohol in which the specimens of the deep-sea soundings which I examined were preserved.

"The strange thing is, that this inorganic precipitate is scarcely to be distinguished from precipitated albumen, and it resembles, perhaps even more closely, the proligerous pellicle on the surface of a putrescent infusion (except in the absence of all moving particles), colouring irregularly but very fully with carmine, running into patches with defined edges, and in every way comporting itself like an organic thing."

Professor Thomson speaks very guardedly, and does not consider the fate of *Bathybius* to be as yet absolutely decided. But since I am mainly responsible for the mistake, if it be one, of introducing this singular substance into the list of living things, I think I shall err on the right side in attaching even greater weight than he does to the view which he suggests.—T. H. Huxley.—(*Nature*, Aug. 19th, 1875.)

A Method for the Microscopic Examination of Sea Water.—By maintaining a uniform high rate of speed, steam navigation has greatly reduced the opportunities for working the towing net, and many of those who want to study surface zoology are compelled to resort to other contrivances. I have found the following plan so efficient that perhaps others may have an interest in its description.

It is, of course, if practicable, desirable to examine the water without disturbing it so much as to interfere with its ordinary conditions. Raking it with a towing net was in one sense a clumsy operation, for all the minute forms which had not been eaten by larger ones escaped, and the captives were drawn through the water in a way likely to influence both their appearance and their action. In a ship at sea and under steam it is possible to raise water for examination with very little disturbance, if you can "fish" from some part of the ship where the forward swing of your apparatus as you raise it from the water does not bring it into contact with any part of the vessel.

The dipper should be a hemispherical tin cup leaded on one half the edge in such a way that it will scoop under the water that it raises, which can then be gently poured into a beaker for examination. Lowering down the beaker itself is a better plan still, for the second disturbance is thus avoided.

In this way I have frequently captured Appendicularia without frightening it out of its "haus," and I have never seen attached Cerithium taken by any other method. But accidents cannot always be guarded against, and the objection to this system is that one's whole stock of beakers is soon disposed of. An ordinary beaker holding about a gallon and a half makes a better and stronger examination tank than a vessel with parallel sides; for although an object floats out of sight on either side, yet the condensation of the light along one side and the easy rotation of the water is very useful if the organisms searched for are small.

When not in use the beaker is easily suspended from the roof of the cabin by a wire round its rim, and can thus swing in safety.

However optically pure the sea water may appear under ordinary circumstances, yet a strong ray of light passed through it in one part will mark its track by myriads of minute specks, almost every one of them an independent organism, for there is little or no mere dust in the open sea. The water of course varies greatly in this respect at different times and places. The nearest approach to optical purity that I have come across is in the cold water that rises to the surface in patches off Cape Finisterre and its neighbourhood to the southward.

About there, one dip may bring up water swarming with life—Diatoms in needles or spirals, or aggregated in glutinous masses, Thalassicollida, Noctiluca, Acanthometrina, Sagitta, and the Tunicates may be present in abundance—and the next will be two or three degrees cooler and show nothing but a glancing diatomaceous needle and the inevitable little light-loving Entomostraca. Any artificial light, even a common candle, is to be preferred to sunlight, for the former and your tank are relatively fixed; besides, sunlight, however desirable, is not to be got in the cabins or wardroom of a man-of-war, and naval etiquette interdicts a seat, much less a microscope on deck. When properly illuminated there is no difficulty in picking out the larger objects with a dip-tube and dropping them into a suitable cell. But all this occasions the third and fourth disturbances of the water, and, if an Appendicularia is captured enclosed in his "haus," he is perfectly certain to be frightened out of it before he gets under the microscope. To avoid the last disturbance I have made a dip-tube with thin parallel sides which could be used as a slide or cell. My first attempts were too large, and the water ran out when the tube was placed horizontally across the stage of the microscope, but I finally succeeded in producing a tube which works fairly well.

The more minute creatures along with the hosts that are invisible to the naked eye, excepting as a whiteness in the track of the ray, are best collected for observation by a small-bore siphon, with a shred of cotton wool in the short arm.

The water should pass through by drops, and the filtrate will after a time be almost perfectly clear. It does not remain so, however, for after some hours it becomes faintly cloudy, though I cannot detect the cause with the microscope.

The filtrate is very useful to keep one or two specimens in if there is anything about them in a transitional state. I have thus watched part, but unfortunately not all, of the development of the groups of spermatozoids sometimes met with on Noctiluca.

The cotton wool first entangles Chætoceros and any united diatoms, and soon becomes completely plugged, at least in the Pacific waters, with Peridinia, young Polycystina, and Foraminifera, together with many other forms that I cannot even class without books of reference.—Edward L. Moss, M.D., F.R.C.S.I., Royal Naval Hospital, Esquimalt, Vancouver's Island.

Spermatozoa of Petromyzon.—Mr. George Gulliver, F.R.S., communicates the following note to the Proceedings of the Zoological Society of London, April 20th, 1875.

In my paper "On certain Points in the Anatomy and Economy of the Lampreys," published in 1870 (P. Z. S. 1870, p. 844), there is an engraving of the spermatozoa of *Petromyzon planeri*. But I know not that those of *P. marinus* have ever been described or depicted; they differ curiously in the two species.

The spermatozoa of *P. marinus*, notwithstanding the great size of the species, are much the smallest, and have a distinct and rounded head. Their mean length is about $\frac{1}{4000}$ inch, and their thickness $\frac{1}{48000}$. They were obtained from a fish 32 inches in length and three pounds in weight, taken on the 12th of May, 1874, in the river Stour, near Sturry Mill, about two miles below Canterbury. The milt, which distended the whole abdomen from the pericardium to the anus, was a soft pulpy mass chiefly composed of a creamy semen, and so rich in, and crowded with, spermatozoa of such minuteness that they were with difficulty distinguishable; and it was not before the semen had been much diluted and placed under Powell and Lealand's $\frac{1}{16}$ objective that a good view of them was obtained. Under a lower power, especially in the pure semen, nothing more than congeries of indistinct rounded points appeared, like those which I have described in the 'Proceedings' of this Society (P. Z. S. 1842, p. 99), as the "molecules of the semen." In short, unless great care be taken, the spermatozoa in the ripe testis are so very faint, minute, and abundant, that they are likely to escape detection.

But the spermatozoa of the little *Petromyzon planeri* are much larger and more easily seen. They are club-shaped, without a distinct head, and have an average length of $\frac{1}{2000}$ inch, and a thickness of $\frac{1}{30000}$. They were obtained in April from a fish 6 inches in length and 2 drachms in weight. Further details concerning the generative organs of both sexes are given in the paper first quoted in the present communication.

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

BOTANY.

Sexual Reproduction of Thallophytes (Supplement).

Every microscopist is familiar with the members of the Protococcoid group of algæ, but it is astonishing how very vague our knowledge of the life history of the greater part of them still remains. Speaking in general terms, it exhibits three distinct stages:—1, a non-motile vegetative phase, in which ordinary cell-division may take place; 2, a motile condition, in which the protoplasm of the quiescent cells divides into a small number of portions—macrozoospores (which germinate asexually), or by a continuation of the process into a large number of portions—microzoospores (which conjugate, but otherwise in most cases appear incapable of germination); 3, a resting stage, in which the green colour of the chlorophyll gives place to a red hue. The non-motile conditions have been placed by systematic algologists in the genera of *Protococcaceæ* and *Palmellaceæ,* and have been mostly limited by insecure diagnostic characters such as the degree of diffluence of the mother-cell-wall, or the manner in which the daughter-cells remain for a time aggregated. On the other hand, the motile phases have to be sought in *Volvocineæ* amongst the species of the genus *Chlamydomonas.*

It will be convenient to sum up briefly what appears to be the present state of our knowledge as to three of the most common types.

Chlamydococcus.—Cohn's study of *Ch.* (*Protococcus*) *pluvialis* [1] still remains the most complete account of the life history of any member of the group. As I have already stated (p. 303), Velten has described what he believed to be the conjugation of the macrozoospores. Rostafinski has, however, obtained further confirmation [2] of his own statement that what Velten saw were merely zoospores destroyed by a parasitic monad. One of Velten's figures (fig. 9) Ros-

[1] Ray Soc. 'Bot. and Phys. Mem.,' 1853, p. 517.
[2] 'Mém. Soc. Sc. Nat. de Cherbourg,' 1875, p. 144.

tafinski considers a monstrosity arising from the adhesion of two macrozoospores, a circumstance which he believes often to happen. It must be very difficult to discriminate such an adventitious adhesion of a pair of zoospores from the actual process of conjugation. In this case, however, since macro- and not micro-zoospores were in question, an adhesion and not a conjugation is probably the right explanation. Rostafinski now regards *Chlamydococcus* as altogether asexual. The microzoospores which are produced during the night have the singular property of collecting on the side of the vessel in which they are placed which is least illuminated. Cultivated in one of Van Tieghem's cells, they passed into the resting stage, assumed a red colour, gradually acquired the size of the normal resting cells, and finally gave rise, by division into four, to zoospores. Rostafinski has also found that *Chlamydoccus pluvialis* is able to exist on snow and in ice, and considers that it and *Ch. nivalis* are identical. He therefore substitutes Agardh's generic name *Hæmatococcus* (1828) for A. Braun's (1851). He further identifies with *Hæmatococcus Volvox lacustris*, which Girod-Chantrans described (in 1797) as giving a fine red colour to water near Besançon, and proposes, on the principles which are adopted by many foreign botanists, to rename the plant *Hæmatococcus lacustris* (Girod).

Protococcus.—The genus which Agardh founded (1824) under this name has furnished material for *Protococcus*, Kütz., in which the cells are isolated; *Pleurococcus*, Menegh., where they are quaternate; and *Cystococcus*, Näg., which has them irregularly aggregated. Rabenhorst suggests that *Protococcus viridis*, the solitary species of the genus, may be a state of *Pleurococcus vulgaris*. *Protococcus*, in its restricted sense, is supposed not to exhibit any increase of its quiescent stage by cell-division. But this may be due to unfavorable external conditions. *Pleurococcus vulgaris*, on the other hand, is stated not to develop zoospores.[1] The two modes of reproduction are therefore in this case mutually exclusive. *Cystococcus humicola* supplies many lichens, such as *Parmelia parietina*, with their gonidia; under these circumstances they still retain the power of producing zoospores.[2]

[1] 'Micrographic Dictionary,' under *Chlorococcum*. *Ch. vulgare*, Grev., is a synonym of *Pleurococcus vulgaris*. The editors of the last edition of the 'Micrographic Dictionary,' forgetting this, have given a full description and figure of the species under *Chlorococcum*, and have added a further description and figure (both from Rabenhorst) under *Pleurococcus*.

[2] Famintzin and Baranetzky, 'Ann. des Sc. Nat.,' 5e sér., vol. viii (1867), p. 137; Woronin, vol. xvi (1872), p. 324.

Chlamydomonas.—The species of this genus are probably all motile stages of forms which are placed in other genera. *Ch. Pulvisculus*, the least known, could be traced, according to Kützing, into *Stigeoclonium stellare;* but he probably confused with it the zoospores of that alga. With more probability Cienkowski has described the development of the macrozoospores into a species of *Glœocystis*, which only differs from *Pleurococcus* in the thicker walls of the cells, and is hardly generically distinct. It is true that his figure shows a more rounded contour than the ovoid zoospores of *Chlamydomonas* usually possess. But as he has traced the same course of development in two other species of the genus, it is exceedingly probable that *Glœocystis* or *Pleurococcus* is the normal quiescent stage which they all attain. The authors of the 'Micrographic Dictionary' describe under the head of *Protococcus viridis* a Pleurococcoid alga which would probably be placed by Rabenhorst under *Glœocystis*, and of this they also state that a *Chlamydomonas* is the motile stage. Reinhardt has observed the conjugation of *Chlamydomonas Pulvisculus*,[1] and Gorojankin states that he has seen this take place between a macro- and a micro-zoospore,[2] an observation which, if confirmed, may be compared with what takes place in *Pandorina.* Rostafinski has also observed the conjugation of the microzoospores of *Ch. multifilis*, Fres. The zygozoospore, after about six weeks, developed by cell-division into a Pleurococcoid alga.[3] It appears, therefore, probable that this stage is reproduced in all cases under particular suitable conditions by both macrozoospores and zygozoospores.

Pandorineæ.—In considering the position which the *Volvocinaceæ* hold in Sachs's classification, I found myself confronted by the same difficulties which had also struck Cohn (see *supra*, p. 312). The group, in point of fact, includes two distinct types of reproduction; and it seemed to me justifiable—taking into consideration the importance, on the whole, of the points which Sachs's classification brings out—to run the risk of doing some violence to what at first sight appears to be a natural assemblage of genera in order to bring it into conformity with that classification. I accordingly proposed (p. 310) to limit *Volvocineæ* to *Volvox* and *Eudorina.* The remaining genera which are usually also placed amongst the *Volvocineæ* I proposed to separate under the name of *Pandorineæ.* Within the last few weeks I have received,

[1] 'Bot. Jahresbericht,' 1873, p. 22.

[2] Quoted by Rostafinski, 'Mém. Soc. Cherb.,' l. c., p. 146.

[3] 'Bot. Zeit.,' 1871, p. 787.

through the kindness of Dr. J. Rostafinski, a copy of the paper from which I have already quoted, and in which I find he has proposed to rearrange the *Volvocineæ* in the same way as I have done, and to constitute a new family, to which he had also given, apparently simultaneously, the name of *Pandorineæ*.

According to Rostafinski,[1] Hieronymus, since the autumn of 1872, has observed at Halle the conjugation of the microzoospores of *Gonium*.

Hydrodictyeæ.—Rostafinski makes the interesting announcement that (as I suggested was likely to be the case[2]) the microzoospores of *Hydrodictyon* have been observed to conjugate by Suppanetz in Prof. De Bary's laboratory. The conjugation takes place while the zoospores are still within the mother-cell, or immediately after their emission. Not only two, but three and even six, zoospores take part in the formation of the isospore. That the zoospores of the same mother-cell should conjugate seems at first sight remarkable, but when it is remembered that from 30,000 to 100,000 are produced from each cell the whole mass of protoplasm must be so enormous relative to each individual zoospore that there is room for the amount of differentiation, which is at the bottom of the sexual process, to exist between the zoospores from different parts of the cell. The formation of the zygozoospore from more than two zoospores is also interesting as confirming Sachs's view that the formation of the plasmodium of the *Myxomycetes* is to be regarded as a sexual process, and it is not superfluous to remark that numerous antherozoids effect the fertilization of the oosphere of the higher algæ, such as *Volvox*, *Vaucheria*, and *Fucus*.

Ulvaceæ.—Janczewski and Rostafinski have failed[3] to confirm Areschoug's observations on conjugation in *Enteromorpha compressa*. They observed the microzoospores attach themselves in pairs by their beaks, but after a time these separated. They also met with pairs partially united together, and these they consider to be monstrous conditions by which Areschoug has been misled. On the other hand, they satisfied themselves that the microzoospores are incapable of germination, and were consequently unable to attribute to them any function. Thuret found the zoospores of *Enteromorpha clathrata* "tous réunis deux à deux par le rostre,"[4] and this has been regarded as a monstrous condition. In *Cladophora glomerata* Cohn observed the fusion of two to five zoospores into a

[1] Loc. cit., p. 146. [2] *Supra*, p. 304.
[3] 'Mém. Soc. Sc. Nat. de Cherbourg,' 1874, p. 372.
[4] 'Ann. des Sci. Nat.,' 3e série, xiv, p. 244.

rotating mass.[1] In *Hydrodictyon* he also figured a double spore. In all these genera in which these monstrous unions have been observed normal conjugation is now believed to take place. It is very difficult to suppose that the two things have nothing to do with one another.

Hydrogastreæ.—Rostafinski has made a most interesting discovery respecting *Hydrogastrum*. This curious little alga has hitherto been placed amongst the *Siphophyceæ*.[2] It turns out, however, not to belong to the *Oosporeæ*, but to the *Zygosporeæ*. The resting spores which have been described by Cienkowski under the name of *Protococcus botryoides*, when placed in water, give origin to zoospores which immediately conjugate. This takes place, Rostafinski assures me, with sufficient precision to enable it to be employed as a class demonstration. Inasmuch as Sorokin has observed conjugation in the Chytridineous genus *Tetrachytrium*,[3] it may be suggested that the real affinity of *Hydrogastrum* is with the *Chytridieæ*. There will then be a relation between *Hydrogastreæ* and *Chytridieæ* amongst *Zygosporeæ*, similar to that between *Siphophyceæ* and *Siphomycetes* among *Oosporeæ*.

Rostafinski proposes that Sach's ZYGOSPOREÆ should be divided into *Isosporeæ* and *Conjugatæ*, the former group to contain all forms in which the conjugation of zoospores occurs. What Areschoug terms a zygozoospore he proposes to call an isospore. There can be no doubt that this is a pleasanter terminology to use.

Volvocineæ.—The observations of Carter upon *Eudorina* have been confirmed by Gorojankin.[4]

Siphophyceæ.—In *Bryopsis* Janczewski and Rostafinski consider[5] that the bodies which Pringsheim supposed to be the antherozoids (*supra*, pp. 313, 314) are really parasitic Chytridineous organisms. It is an open question so far whether *Bryopsis* may not, like *Hydrogastrum*, turn out to belong to the *Zygosporeæ*. The zoospores also exhibit the propensity to "agglomerate," and, judging from other instances, this suggests the probability that they conjugate also.

Phæosporeæ.—Janczewski and Rostafinski[6] studied zoospores of various species at Cherbourg during 1872, with

[1] I have copied one instance from him (*supra*, p. 305). Perhaps I should have put a ? after 'Conjugation.'

[2] E. Parfitt has given a strangely erroneous account of its life-history in 'Grevillea,' vol. i, pp. 103-105.

[3] *Supra*, p. 307.

[4] *Supra*, p. 310; Rostafinski, l. c., p. 145.

[5] Loc. cit., p. 375.

[6] Loc. cit., p. 371.

especial reference to the possible occurrence of conjugation amongst them. They failed entirely to detect anything of the kind, the zoospores coming to rest and germinating within twenty-four hours. They conclude, therefore, that the problem of the sexuality of *Phæosporeæ* will be solved, not by the further study of the zoospores of these algæ, but by the detection of female organs which have hitherto eluded observation.

I must conclude with an historical reclamation. I am indebted to Dr. Carpenter for pointing out to me that in 1848 Thwaites[1] indicated that sexuality existed in its most generalised form in conjugation, a view of which I attributed the first conception to De Bary (*supra*, p. 299) ten years later.

I may also add that, as early as 1854[2] Cohn pointed out the morphological parallelism which exists amongst Thallophytes in which chlorophyll is present and those in which it is absent.

W. T. THISELTON DYER.

[1] 'Ann. Nat. Hist.,' 2nd series, vol. i, p. 163.
[2] 'Nov. Act. Acad. Nat. Cur.,' vol. xxiv, p. 141.

PROCEEDINGS OF SOCIETIES.

Royal Microscopical Society.

December 2nd, 1874.

A paper was read by Dr. Hudson "On the Discovery of some New Male Rotifers." The author describes the male of *Lacinularia socialis*, which he observed in numbers, as hatched from the eggs of one female. He describes it as consisting of little else than a large testis, ending in a hollow cylindrical penis, and nearly filling the whole internal space of the body. Of mouth, œsophagus, mastax, or stomach, it has not even a vestige. There is a large nervous ganglion, giving off nervous threads to two red eyes and a dorsal antenna. Tortuous tubes with vibratile tags were visible above the testis, and could be traced partly down the animal's sides; while above the testis, between it and the ganglion, was repeatedly seen the delicate outline of a contractile vesicle, this really holding its normal position with respect to the testis, and only apparently thrust out of its proper place by the monstrous size of that organ. Large cilia could be seen lining the passage through which the penis could be protruded, as well as the cup which terminated the short-jointed foot.

The male of *Floscularia campanulata* was also observed, so that the author regards the diœcious character of these two genera as established. He discusses the bearings of these facts on the zoological position of the *Rotifera*. Figures are also given of the males of *Notommata brachionus*, and of a new species of *Asplanchna*.

A paper was taken as read by Dr. Schmidt, of New Orleans, on "The Development of the Smaller Blood-vessels in the Human Embryo." It contained the results of observations made at different dates. According to the earlier observations the formation of the smaller blood-vessels appeared to take place in two different modes. The one, belonging to the earlier mode of development, was observed to consist in a coalescence of certain cells, while by the others, at a somewhat later period, the formation of the blood-vessels was effected by the fusion of certain spindle-shaped bodies. The author believes both observations to be correct, the discrepancy being merely apparent.

On December 9th a "scientific evening" was held.

January 6th, 1875.

CHARLES BROOKE, Esq., F.R.S., President, in the chair.

Dr. W. M. Ord read a paper on "Studies in the Natural History of the Common Urates." The author described some of the forms assumed by urate of soda and urate of ammonia, both as occurring in pathological conditions and as produced artificially.

A paper by Dr. Pigott "On the Invisibility of Minute Diffracting bodies, caused by Excess of Aperture, and upon the Development of Black Aperture, Test-bands, and Diffraction-Rings," was also read.

February 3rd.

CHARLES BROOKE, Esq., F.R.S., President, in the chair.

The following gentlemen were elected as officers and Council for the ensuing year:—

President.—Henry Clifton Sorby, F.R.S.

Vice-Presidents.—Robert Braithwaite, M.D., F.L.S.; Charles Brooke, M.A., F.R.S.; John Millar, L.R.C.P., F.L.S.; William B. Carpenter, M.D., F.R.S.

Treasurer.—John Ware Stephenson, F.R.A.S.

Secretaries.—Henry J. Slack, F.G.S.; Charles Stewart, M.R.C.S., F.L.S.

Council.—Frank Crisp, LL.B., B.A.; John E. Ingpen; Samuel J. McIntire; Henry Lee, F.L.S.; William T. Loy; Henry Lawson, M.D.; John Matthews, M.D.; George Shadbolt; Charles Tyler, F.L.S.; Frederic H. Ward, M.R.C.S.; Francis H. Wenham, C.E.; Charles F. White.

The Secretary read the Treasurer's annual statement of accounts and the annual report of the Council. It appeared that seventeen Fellows, one Corresponding and one Honorary Fellow, had been elected during the year, while ten Fellows and one Associate had died. The financial position of the Society was satisfactory.

The retiring President delivered an address, in which he made some remarks upon the improvement in object-glasses. He said—

"The past year has been marked by decided improvement in object-glasses. A remarkably fine one-eighth has been made by Messrs. Powell and Lealand, with an avowed single front lens; but how far its principle of construction may agree with or differ from that previously enunciated by Mr. Wenham cannot at present be stated, as its construction has not been made public. The image formed by this lens bears amplification by very deep eye-pieces exceedingly well, than which there is no more certain test of first-rate definition.

"In the object-glasses constructed upon Mr. Wenham's formula considerably increased flatness of field has been obtained by substituting two plano-convex lenses, of proportionately less curvature, for the single plano-convex posterior lens formerly employed. The writer has in his possession a one-seventh on the improved model and can without hesitation affirm that it is superior in definition, and far superior in clearness and absence of fogs or milkiness, to any other objective he possesses, these comprising a one-sixth and one-eighth by Andrew Ross, a one-fourth and one-twelfth by Thos. Ross, and a one-sixteenth and one-twenty-fifth by Powell and Lealand; all considered first rate by their respective makers."

March 3rd, 1875.

H. C. Sorby, Esq., F.R.S., President, in the chair.

Mr. H. J. Slack made some remarks upon the organism previously exhibited by Mr. Badcock, and thought to be the same as *Bucephalus polymorphus* of Von Baer, and believed to have come from a fresh-water mussel. Mr. Slack quoted abstracts and exhibited figures from Von Baer's paper (in the 'Nova Acta' of the Leopold Carolinean Academy of Bonn, for 1826, p. 570) which left no doubt on his mind of the identity of Mr. Badcock's specimen with that described by Von Baer.

Another species, *Bucephalus Haimeanus*, had been described by Lacaze-Duthiers in the 'Annales des Sciences Naturelles,' 4me série, tome i, who found the abdominal organs of oysters and cockles completely invaded by the sporocysts of this parasite. Other descriptions of this species had been published by Claparède ('Beobachtungen über Anatomie, u. s. w., an der Küste von Normandie,' 1863), and Alf. Giard ('Comptes Rendus,' Aug. 17, 1874).

Mr. Badcock thought that the animal described by him could not be identified with Von Baer's, though it might belong to the same class of animals, and stated that Professor Huxley, who had first suggested its identity with *Bucephalus polymorphus*, had since doubted this.

Dr. G. W. Royston-Pigott read a paper "On the Principle of Testing Object-glasses by the Coloured Images produced by Reflexion from a Globule of Mercury and on Eidola."

Mr. Wenham explained to the meeting a new "Method of Obtaining Oblique Vision of Surface-structure under the Highest Powers of the Microscope."

April 7th, 1875.

H. C. Sorby, Esq., F.R.S., President, in the chair.

A paper by the Rev. W. H. Dallinger and J. Drysdale, M.D., on "Further Researches into the Life-history of the Monads," was taken as read.

This paper completed the series commenced some four years before on "The Developmental History of Monads." Referring to the chief forms which they had observed successively at different times in the maceration of animal tissues, the authors remark that simple conditions of season and temperature may account for their successive appearance in the fluid, without supposing that one form was developed out of another, *i. e.* without having recourse to the startling hypothesis of heterogenesis. Their observations, they are bound to say, gave no countenance to this doctrine. On the contrary, the life-cycle of a monad is as rigidly circumscribed within defined limits as that of a mollusc or a bird. There is no indication of any unusual or more intense methods of specific mutation than those resulting from the secular processes involved in the Darwinian law, which is held to furnish the only legitimate theory of the origin of species.

They do not agree with Billroth as to the sameness or monotony of specific forms in putrefying animal matter. This may be true in the earlier styles of putrefaction, but not in the later, when flagellate forms appear, sometimes extinguishing the bacteria and their congeners, and play, as the authors believe, an important part as active agents of putrefaction.

The life-cycle of several forms having now been traced, it is seen that in no instance was the continuance of the species maintained without the introduction of a sexual process, a blending of what were shown in the sequel to be genetic elements.

The experiments as to the effect of heat on the monads and their spores uniformly established an important fact, viz. that the spores resist heat much better than the adults. A temperature of 150° F. was always found to destroy utterly all the adult forms, while the spores resulting from sexual generation have a power of resistance to heat which is greater than this in the proportion of eleven to six on the average. "*This appears to us*," they say," *to be the very essence of the question of Biogenesis versus Abiogenesis.* In some, at least, of the septic organisms spores are demonstrably produced, and these spores can resist a temperature nearly double that of adults on the average; that which some can resist is 88° F. above the boiling point of water." This is in harmony with the experiments of Roberts and the later ones of Huizinga.

The President read a paper "On some New Contrivances for the Study of the Spectra, and for Applying the Mode of Spectrum Analysis to the Microscope." He exhibited and explained a new apparatus for employing an ordinary eye-piece in connection with a slit and prisms, and also the binocular spectrum microscope. Mr. Sorby still employs the quartz interference scale for the measurement of bands, but proposes for the future to adopt the plan now employed in the case of luminous spectra, and express everthing in terms of wave-lengths. For this purpose he has constructed a table giving the wave-lengths of every one-eighth division of his quartz interference scale, so that, having measured the position of any part of the spectrum by means of this scale, he can at once, by the table, express everything in terms of millionths of a millimeter of wave-length. He proposes to publish this table, and also the means of correction for other scales not accurately corresponding, so that every observer may express measurements made by his own scale in accurate wave-lengths. Some interesting relations of spectra are at once shown by the wave-length method.

May 5th, 1875.

H. C. Sorby, F.R.S., President, in the chair.

Mr. Slack read a paper "On Angle of Aperture, and its Relations to Surface-markings and Accurate Vision," in which he advocated the use of objectives with a small angle of aperture especially by naturalists and physiologists, thinking that opticians had been encouraged to make excessive apertures substitutes for good corrections. He referred especially to the high powers made by Zeiss, of Jena, with a small angle.

The President expressed his entire concurrence with Mr. Slack's remarks.

Mr. Stephenson, Dr. Pigott, and Mr. Stewart spoke highly of the glasses of Zeiss.

A paper by Dr. Braithwaite "On Bog Mosses" was taken as read.

On April 21st, 1875, a "Scientific Evening" was held in the Library of King's College.

June 2nd, 1875.

Charles Brooke, Esq., F.R.S., Vice-President, in the chair.

Mr. Stephenson exhibited and explained "A Scale for the Measurement of Angular Aperture."

Mr. Stewart made some remarks on *Bucephalus polymorphus*.

Mr. Slack read a paper "On the Use of Mr. Wenham's Reflex Illuminator."

The proceedings were then adjourned till October.

Medical Microscopical Society.

Friday, March 19th, 1875.

Dr. J. F. Payne, President, in the chair.

Spinal Cord in Infantile Convulsions.—Dr. Sidney Coupland exhibited specimens from the case of a child, æt. 6 months, dying in convulsions, secondary to cancrum oris. He described great dilatation of the capillaries and small vessel of the cord, especially in the commissural part of the grey cornua, and enlarged perivascular spaces, the maximum of enlargement being in lower part of medulla, particularly near the central canal, but the canal itself and its epithelial lining seemed perfectly healthy. He considered the perivascular dilatations are most probably secondary to the convulsions and not their cause, but due to over-distension of the vessels during hyperæmia of the cord, and drew attention to the similarity of the appearances now seen, to those described by Dr. Dickenson in cases of diabetes.

Mr. Needham has observed the same changes in the brain in cases of hydrophobia, and in cases of heart disease where there had been much congestion.

The President thought the changes described not uncommon; they were mentioned long ago by Durand-Fardel, as owing to wasting of the brain in old age, and lately by Dr. Lockhart Clarke in paralysis of the insane. These appearances may not be pathognomic, and Dr. Dickinson could not find them in the parts of the brain which when injured cause diabetic condition; they are found too in seemingly healthy brains. His first described the perivascular spaces, and by some they are considered lymphatic, but the name is usually given to the tunica adventitia of the artery separated, and under diseased conditions filled with blood or inflammatory material. In the case given it was not likely the spaces were owing to simple mechanical distension of the vessel, for if so, why should the vessel not remain distended? it would scarcely again collapse. They were more easily explained by wasting of the brain substance, and consequent filling of the perivascular spaces—whether tunica adventitia or not—with serum, since a vacuum cannot exist, and this wasting, a severe illness, or bad feeding might bring about.

Dr. Greenfield had always observed a catarrhal condition of the central canal of the cord in cases of convulsions; and what the President described as tunica adventitia, he thought an additional structure to help support the vessel.

Dr. Coupland, in reply, stated he had in preparing the spinal cord preserved it first for twenty-four hours in spirit and water, and then in weak chromic acid. He did not know if the child were badly nourished, nor how long it had been ill.

Urate of Soda in the Heart.—Mr. Ward exhibited a specimen where, in a gouty subject, the coronary artery was found plugged, the plug containing acicular crystals of urate of soda. Death was sudden, from rupture of left ventricle; the heart substance was friable.

The President had seen sudden death in cases of plugging of the coronary artery.

Dr. Greenfield stated that fatty change in the heart was said to follow plugging of the coronary arteries—he had not observed it uniformly. He quoted Dr. Quain's cases of plugged coronary artery; in all death was from ruptured heart.

Mr. Golding Bird asked if any chemical test had been applied to the crystals. He had once succeeded in obtaining under the microscope, by the addition of weak acid, crystals of uric acid, from the acicular crystals of urate of soda contained in a section of "gouty" cartilage.

Mr. Ward, in reply, had not applied any chemical test; the heart substance was not fatty, and he did not know which coronary artery was plugged. The crystals did not polarize.

Blood Crystals from Rat, exhibited by Dr. Pritchard, were obtained after killing the animal with ether: a drop of the blood with water is placed in a glass cup and covered at once; on coagulation, the crystals are seen in the spaces between the fibrin. If cemented thus they keep a long time, being in vacuo.

Myxoma, a specimen exhibited by the President in which the connecting filaments were apparently tubular and not merely as often described, flat or thread-like processes. The preparation was in glycerine, but the same appearance was seen when fresh. The specimen is figured in 'Trans. Path. Soc.,' vol. xx, p. 344, and in Jones and Sieveking's 'Pathological Anatomy,' 2nd ed., page 138.

Friday, May 21st, 1875.

Dr. J. F. Payne, President, in the Chair.

Fatty Degeneration of Muscle.—Notes on this subject were read by Dr. Kesteven. He observed that the expression "fatty degeneration" as usually employed was a misnomer; that the change is one in which as a matter of fact fat plays no part at all. Instead of fatty matter the degenerated muscles exhibit a disintegration of the contents of the muscle fibrils, obliterating their striation. Along the centre of these are to be seen dark brown or black granules of a pigmentary character, not removable by ether or alkalies. The change begins and ends in the fibrils, and is very distinct from the fatty condition, in which the fibrils, retaining their striation, are separated by deposition of adpoise tissue. The latter form of disease is more or less associated with changes in the nervous centres, while in the former it is not so. Preparations and illustrative drawings were exhibited by the author of muscular atrophy, pseudo-muscular hypertrophy; rupture of the left ventricle; infantile paralysis, and the so-called fatty degeneration.

The President and several of the members took part in the discussion that followed.

Myelitis.—A paper on this subject by Mr. D. J. Hamilton was read by the President, which is printed entire at page 335 of this number of the 'Quarterly Journal of Microscopical Science.'

After a brief discussion on the paper Mr. Groves described and exhibited Crouch's improved fine adjustment for microscope stands made on the Continental model, in which great stability was combined with easy and regular motion, the points of friction being reduced to a minimum. He also described a centering substage arrangement for the same stand.

Dublin Microscopical Club.

March 18th, 1875.

Observations as to the Appearance of Hexagonal Markings on Pulvilli of Flies' Feet.—Mr. Porte drew attention to the hexagonal and lozenge-shaped markings frequently observed on the under surface of the pulvilli of flies' feet. He considered that this appearance had been misinterpreted, and that the markings are not corrugations of the membrane, but are really produced by the compression of the tubular hairs with which the under surface is clothed, like velvet pile. He pointed out a portion of the foot which was torn and which exhibited the hairs separated a little from one another and retaining the hexagonal shape produced by the compression.

Diatoms from a Freshwater Deposit found in Vancouver's Island.—Rev. E. O'Meara reported on a sample from a freshwater diatomaceous deposit recently sent by the Club's corresponding member, Dr. Moss, R.N., found on Vancouver's Island. Mr. O'Meara called special attention to one form, which occurred with tolerable frequency, identical with that which a few meetings previously he had submitted to the Club, found by him in Lough Neagh, near Lurgan, and named by him *Navicula Kittoniana.* This species had been previously described by Mr. Kitton, who considered it identical with *Navicula americana*, Ehrenb., but Mr. O'Meara having had the opportunity of inspecting some specimens of the last-named species (kindly supplied by Mr. Kitton), he considered that the form in question is distinct from *Nav. Bacillum*, but identical with *Nav. americana;* in the former the frustule is much smaller, perfectly linear, and the striæ extend much nearer the median line; in the latter the frustule is constricted, the band of striæ not reaching the median line.

Zoospore Condition of Noctiluca.—Dr. Moss, R.N. (corresponding member of the Club), showed some elegant drawings of the zoospore condition of Noctiluca, which he had independently worked out, at the time unaware of Cienkowski's Memoir, in Schultze's 'Archiv f. mikr. Anatomie,' descriptive of their development.

Rotifer citrinus, exhibited.—Dr. J. Barker exhibited a rotifer he considered to be *Rotifer citrinus* ('Pritch. Infus.'), the trochal discs less separated, the body more yellow-coloured than in *R. vulgaris*, and showing longitudinal plicæ.

Cosmarium holmiense, *β*, Lundell, *and Cosm. anceps*, Lundell, *new to Ireland.*—Mr. Archer recorded the occurrence in the same gathering and showed examples of *Cosmarium holmiense*, *β*, Lundell ('De Desmidiaceis,' p. 40, t. II, f. 20), and *Cosmarium anceps*, Lundell ('De Desmidiaceis,' p. 48, t. III, f. 4), both seemingly new to Britain. They were taken on Bray Head. The only previous examples of *Cosm. holmiense* he had seen were those brought from the Falls of the Rhine, by Dr. Barker and Mr. Crowe; of the identity there could be no doubt, as both their specimens and those from Bray Head quite agreed in every detail with Lundell's description and figure (l. c.). Mr. Archer, as to the latter species, must quite concur with Hr. Lundell in placing *C. anceps* in Cosmarium and not in Euastrum, and for the reasons given in that author's work.

April 22*nd*, 1875.

Resting Spores of Volvox globator shown by Dark-ground Illumination.—Dr. J. Barker showed the yellow resting-spore of *Volvox globator*—the so-called "Volvox aureus;" also a copious number of examples in the ordinary characteristic condition under his dark-ground illumination, by which they were charmingly seen, the coloration shining out brilliantly.

Puccinia Malvacearum, Corda, *new to Ireland.*—Mr. G. Pim showed examples of *Puccinia Malvacearum*, Corda, which had occurred on Hollyhocks in his garden and threatened their destruction, this being the first record of this Hollyhock-pest in Ireland. The plants had been grown from seeds obtained from England; Mr. Pim, therefore, suggested the question, Can the germs of the Puccinia have been already in the seeds, as those of Cystopus are stated by de Bary to find their way into certain Cruciferæ through seeds? The present examples quite agreed with the figures given in 'Grevillea,' Dec., 1874.

Sections of Leaves of Pinus Pattoniana and P. Hookeriana, exhibited.—Dr. McNab showed sections of the leaves of *Pinus* (Tsuga) *Pattoniana* and *P. Hookeriana*, and pointed out the characters by which these two species might be distinguished.

Spicules of Rawsonia elegans, Wright, *exhibited.*—Mr. W. M. A. Wright exhibited specimens of the spicules of *Rawsonia elegans*, Wright = *Calicella elegans*, Gray.

Navicula Barkeriana, n.s., O'M., *exhibited and described.*—Rev. E. O'Meara drew attention to the details of a new Navicula found by him sparingly in two distinct localities, namely, Dalkey, Co. Dublin, and the Breeches, near Newcastle, Co. Wicklow. The valve is linear, elliptical, gradually attenuated towards the produced ends; striæ fine, close, linear, distinctly radiate, intermediate, unstriate, space wide in the middle, extending nearly to the margin, median line terminating at the central nodule in elongated pear-like expansions. Length, 0052″; breadth, 0014″. This form might on casual inspection be confounded with *Navicula latiuscula*, Kuetz., but on closer examination will be found to differ in the following details of structure: the free intermediate space between the inner ends of the striæ is much wider; the ends instead of being simple are, in this case, produced; the striæ are much coarser and radiate. Besides, the form is marine, whilst *Nav. latiuscula* is incidental to freshwater. Mr. O'Meara proposed to designate the species *Navicula Barkeriana.*

Structure of Spine of Strongylocentrotus armiger, A. Agass.—Mr. H. W. Mackintosh showed a section of the spine of *Strongy-*

locentrotus armiger, A. Agass. The spines of this species are very like those of Echinometra described in the Club Minutes of September, 1874, but may be distinguished from them by the radiating "spokes" of reticular tissue being united by lateral prolongations of similar structure in *S. armiger*, whereas in Echinometra they are connected by a series of solid bars, which are not joined to one another by any reticulation.

Conjugated State of Stauroneis phœnicenteron, exhibited.—Mr. Archer showed the conjugated state of *Stauroneis phœnicenteron* quite the same as previously described by him, common as the species is, but rarely encountered conjugated. When recent and the contents bright and healthy, this example, as a microscopic object, was an exceedingly bold and handsome one, though since being placed on the slide (some evenings since) it had much lost its beauty.

Crystals of Olivine from Vesuvian Lava and Irish Basalt.—Prof. Hull exhibited thin slices of crystals of olivine from the lava of Vesuvius, and others from the basalt of the north of Ireland. The former, by the aid of polarised light, presented the characteristic rich play of colours, changing on rotating the analyser from crimson to sap-green, or from yellow to blue, or from grey to deep purple; a beautiful banded structure was also sometimes apparent. On the other hand, the material filling the interior of the crystals of the basalt of the north of Ireland exhibited but a faint play of colours, changing from pale grey or green to brown; whilst the interior of the crystals exhibited in some places a concretionary structure. A comparison of numerous specimens of olivine crystals from the Vesuvian lavas with those of the Irish basalts and melaphyres had induced Prof. Hull to come to the conclusion that in nearly all cases the interior of the olivine crystals of the Irish rocks had been replaced by some chloritic or other mineral, and that the specimens seen in these rocks are in reality a pseudomorph after olivine and not the original mineral itself, for it is well known that of all minerals olivine is the most liable to alteration.

Sections of Stem of Lime, exhibited.—Dr. M'Nab exhibited a transverse section of the stem of the lime-tree at the second year's growth. The stem had been hardened by alcohol before being cut into very thin sections; these were stained by being placed for twenty-four hours in Beale's carmine solution. On examination with a moderate power the section showed the cambium layer, the cells of which were densely filled with protoplasm, most of them having the nuclei well developed. On each side of the cambium layer the new permanent tissue could be seen, the xylem part of the fibro-vascular bundles on the one side, the phlöem part on the other. The three elements of the xylem or wood part, viz., the wood-prosenchyma, the wood-parenchyma, and the wood-vessels could be seen, both in the new xylem and in the wood of the preceding year. The three elements of the phlöem, the bast-parenchyma, and bast-vessels, and the bast-prosenchyma were visible both in the new phlöem as well as in that of the first year. The cortical tissues, with the remarkable trumpet-like openings of the medullary rays, were very conspicuous.

Structure of Leaves of Selaginella.—Mr. Pim showed two preparations of leaves of Selaginella (*Selaginella Kraussiana* and *S. Poulteri*), presenting the peculiar epidermal structure. The stomata, which are much smaller than in most Phanerogamia, are found only on the lower surface, and are disposed in three or more rows, in the immediate neighbourhood of the midrib. The epidermal cells on the upper surface are small and nearly circular, while those of the lower surface are large, irregularly trapeziform with waved margins. The leaves were bleached with the nitric acid solution described on a previous occasion, stained with carmine and Judson's blue, and mounted in Deane's gelatine. Mr. Pim had found the same general arrangement in all the species of Selaginella he had examined, the chief variations being the shape and size of the epidermal cells of the under side, and the number of rows of stomata.

Spermatozoids of Volvox globator, exhibited.—Mr. Archer exhibited the spermatic condition of *Volvox globator*, showing the little tabular bundles of collaterally combined elongate spermatozoids, at first enclosed in a globular envelope; in the examples shown a considerable number of the peripheral cells had remained unaltered, whilst in others nearly the whole had become changed into the groups of spermatozoids; other examples showed the resting-cells, preparatory to assuming the golden hue.

Cosmarium cyclicum, Lundell, *new to Ireland.*—Mr. Archer, though the evening was late, still, as the example was perishable, further showed the only specimen he had ever seen or taken of *Cosmarium cyclicum*, Lundell. This example was from Callary, from a small pool all but dried up, which, however, had never been very good for Desmidieæ (but a noted site for the rotatorian, *Conochilus Volvox*). It was quite in accord with Lundell's lower figure ('De Desmidiaceis,' t. III, f. 6 d), and the form must be, he thought, quite distinct from the so-called variety of this species of Nordstedt, "Desmidiaceæ ex Insulis Spetsbergersibus, etc., collectæ" (in 'Öfversigt af Kongl. Veteskaps Akademiens Förhandlingar,' Stockholm, 1872), and even more so from the further "variety" of Reinsch, "Contributiones ad Algologiam et Fungologiam," p. 89, t. x, f. 10, 1875.

27th May, 1875.

On Chytridiæ in the Floridieæ.—Dr. E. Perceval Wright called the attention of the Club to the subject of the presence of Chytridieæ attacking certain Floridieæ. Magnus had very recently described a new species as met with in the young cells of *Ceramium flabelligerum*, near Edinburgh, and suggests that, in the red Algæ, these parasites have often been passed over as abnormal forms of fructification. This may possibly have been the case in the instances quoted by Magnus in 'Die botanischen Ergebnisse der Nordseefahrt' (1872), but it must always be a matter of great difficulty to decide as to the presence of such forms in dried specimens of algæ, as are for the most part met with in collections. Magnus declares that the bodies figured by Harvey ('Phycologia Australis,' Pl. CCXXVII), as probably Antheridia in *Callithamnion dispar* are only specimens of *Chytridium plumula*, Cohn. Dr. Wright now exhibited mounted specimens taken from the identical form figured by Harvey, which, though differing materially from the figure, where the globose bodies in the end cells are, owing to an oversight, printed red in place of yellow, still did not seem to show any marked character of Chytridium. The subject opened up a wide field, well worthy of being closely investigated on the living alga.

Minute Structure of the Leaves of Pinus grandis, Douglas, *and P. lasiocarpa*, Hooker.—Dr. McNab exhibited sections of the leaves of *Pinus grandis*, Douglas, and of *P. lasiocarpa*, Hooker, and pointed out that, although the two names were generally considered to apply to the same plant, still, *Pinus lasiocarpa*, Hooker, was quite distinct from *Pinus grandis*, Dougl., and was apparently not in cultivation in this country. The two forms can at once be separated by the position of the resin canals in the leaf: *P. lasiocarpa* has the resin canals in the middle of the parenchyma, whilst in *P. grandis* they are close to the lower epidermis and near the margin of the leaf.

Structure of Spine of Strongylocentrotus tuberculatus.—Mr. Mackintosh showed the spine-structure of *Strongylocentrotus tuberculatus*, which corresponds in type with that of *Strongylocentrotus armiger* (see 'Club Minutes' of April, 1875), but differs from it in having the solid pieces more quadrilateral than triangular, and in the more open character of the network both in the central portion ("pith," C. Stewart) and in the radiating spokes.

Œdogonium macrandrum, Wittr., *for the first time shown as Irish, and other species exhibited.*—Mr. Archer showed the above, also *Œdogonium acrosporum*, De By., as well as *Œdog. Areschougii*, Wittr.; all must seemingly be accounted as rare with us.

Composition of Volcanic Dust from St. Vincent.—Professor Hull, F.R.S., exhibited under the microscope a little of the fine Volcanic Dust which fell on the Island of Barbadoes on May-day, 1812, having been discharged into the air from the great volcano of St. Vincent during the eruption which commenced three days previously, and at a distance from Barbadoes of 100 miles. The dust was found to consist of angular or sub-angular grains of two kinds of felspar (sanidine and plagioclase), together with grains of magnetite, which were readily attracted by a small magnet. The grains of dust were so small as to be invisible to the naked eye, but became apparent when viewed with the ordinary lens.

Navicula subcincta, Schmidt, *exhibited, new to Ireland.*—Rev. E. O'Meara exhibited a form of Navicula which he found several years since in a gathering made by Professor E. P. Wright at Arran Island, County Galway, and specimens of which he had subsequently found in stomachs of Ascidians taken by Mr. A. G. More in Broadhaven Bay, in same county. This form Mr. O'Meara had considered undescribed, and named it in his private list *Navicula Cleveana*, but happening to glance at a recently published paper by Schmidt, in a work ('Die Botanischen Engebnisse der Nordseefahrt') lying on the table (for quite another purpose) at the time of the meeting, he at once recognised as that described by the distinguished author referred to as *Navicula subcincta.* This name has, therefore, the priority of publication, and so is entitled to stand as the designation of the species, of which the following is the description:—Valve slightly constricted; ends somewhat cuneate; rounded at the extremities. Median fascia broad, inflexed at the ends, and slightly constricted at the middle; external fascia broad acute, unstriate. Striated band marginal, divided into equal portions by a longitudinal sulcus. Striæ costate, parallel in the middle, slightly radiate towards the ends. Length 0·0042″, greatest breadth 0·0016″, breadth at constriction 0·0015″.

Mougeotia glyptosperma, De Bary, *stained by Logwood.*—Mr. Archer showed an example of foregoing, mounted by Professor Thiselton Dyer, after having stained it with logwood. It thus formed a striking object, and this plan seemed calculated to make a good permanent preparation.

Singular and unprecedented Case of Conjugation between two distinct, but allied, Desmidian Species.—Mr. Archer drew attention to two or three cases of conjugation between two distinct, but allied, Desmidieæ,—a similar case he had indeed never before seen or heard of. The species of these algæ always conjugate like with like. Even those closely resembling, but still distinct, Staurastra, confounded under the name of *Staurastrum dejectum*, though crowded together in the same gathering, sometimes one only of the forms, sometimes all of them, being in the conjugating state, still in them conjugation takes place only *like with like.* And so on. But, *mirabile dictu!* here was *Euastrum didelta* and *Euastrum humerosum* mutually conjugated! The zygospore was very large, and densely covered, as is usual in the genus Euastrum, by long, rather thick, finger-like hyaline spines or processes, bluntly rounded at their apices. We must, in explanation of this singular (and, so far as Mr. Archer was aware, unprecedented) fact, suggest one or other of two possibilities. *Either* these two forms are only varieties of a single species, hence a matter of indifference whether conjugation takes place, *didelta* with *didelta*, or *humerosum* with *humerosum*, or *didelta* with *humerosum.* *Or* this was just a mere case of *hybridisum*, similar and comparable to what not unfrequently occurs in higher plants, to which latter view Mr. Archer would be inclined to lean.

Dictyosphærium constrictum, Archer, olim., *found conjugated, and a true, though aberrant, Desmidian.*—Mr. Archer showed examples of the alga which he had previously described in these Minutes ('Quart. Journ. Micr. Science,' vol. vi, n.s., p. 127; also 'Club Minutes,' 22nd May, 1872, and named *Dictyosphærium constrictum*, but as he had now found it conjugated, and exhibited the *zygospores*, it was proven to be, in truth, no Dictyosphærium (Näg.), but a veritable, though aberrant, Desmidian. Besides the cells being combined into a "colony" by branched stipites, much of the general appearance and habit would place this plant side by side with Cosmocladium, Bréb., as, indeed, Mr. Archer had previously mentioned at a former meeting of the Club. But in Cosmocladium the Cosmarium-like cells are placed at the summits of the ramifications of a *double* stipes, whilst here it is *single*. Moreover, this form is characterised by a certain amount of want of symmetry in its outline, and by the arrangement of the contents, both presenting points of difference from Cosmocladium or typical Desmidieæ, thus rendering this form very singular in that family. The zygospore is orbicular, beset by a number of hyaline, terete, subacute, or very rarely slightly bifid spines; the empty membrane of the parent-cells minutely and distantly punctate. This form does not appear to have yet been found out of Ireland, the Rocky Valley, near Bray, being its head quarters. But as a brief "Minute" here would only very inadequately convey a true picture of this species, Mr. Archer would defer a more minute description until he should be able to obtain fresh examples, but he was sorry to say that the form seemed to have suddenly, almost wholly, disappeared from its site, and it might be some time ere he could obtain specimens to enable him to prepare a detailed account of this interesting addition to the ranks of the Desmidiæ.

17*th June*, 1875.

Structure of Leaves of Pinus Mertensiana and P. canadensis.—Dr. M'Nab exhibited sections of the leaves of *Pinus Mertensiana* and *Pinus canadensis*, and pointed out that, although the leaves bear a very great resemblance externally, the two species are readily separated by characters presented by the minute structure. In *P. canadensis* no hypoderm exists, whilst in *P. Mertensiana* the hypoderm is well developed.

Structure of Spine of Hipponoë variegata, A. Agass.—Mr. H. W. Mackintosh showed a transverse section of the spine of the foregoing. The central portion is occupied by very wide reticular tissue, which is surrounded by a ring of ill-defined solid pieces; outside this is a zone of irregular network, which extends out in the form of rays to the grooves on the surface of the spines. Between these rays are the solid "spokes," which dilate at intervals into irregularly-shaped forms, increasing in size from within outwards.

Lejeunia hamatifolia exhibited.—Dr. More showed examples of *Lejeunia hamatifolia*, forming with its delicate structure a very pretty low-power object, and an interesting member of the Irish Cryptogamic Flora, as indicative of the average mildness of the climate.

Navicula undulata, *n. s.*, O'Meara, *distinguished from N. distans.*—Rev. E. O'Meara exhibited a very interesting form of Navicula, which he regarded as hitherto undescribed, and of which the characters are as follow:—Median line undulate; striæ broadly costate, not reaching the median line; costæ in the middle remote, very short, those next somewhat longer, much closer, and finer towards the ends. This form much resembles *N. distans*, but differs from it inasmuch as the median line in the present case is obviously undulate; the costæ, too, are closer, and the ends broader than in that species; length 0·0056″; breadth 0·0013″. Mr. O'Meara proposed to name this form *Navicula undulata.* It was found on seaweeds collected many years since at the Giants' Causeway.

On some seemingly novel or undescribed points of structure in Ballia callitricha, var.—Mr. Archer drew attention to certain points of structure in a species of Ballia, Harvey (*Ballia callitricha*, var.), seemingly not recorded in the descriptive works. The chief of these was the presence of *pits* at either end of the joints of the principal rachides, and of more than two, but smaller, in certain other of the cells of the frond, each of these pits *covered* or *closed up* by a lenticular, hemispherical, or kettle-drum-shaped *lid* or *stopper*. Both in its bearing on this alga, and as an example of a peculiar kind of secondary deposit (?) in a vegetable cell, this structure would seem to have a considerable amount of interest. Another feature, not shown in the books, was the apparent, but only apparent, introversion of the upper ends of the joints (more striking in those of the principal rachides) to receive a *seeming* conical projection of the lower ends of the upper joints. As first suggested by Professor E. Perceval Wright, the state of affairs, however, is quite the reverse. The lower ends of the joints are each laterally cleft or subdivided, and curved off in front like a "bishop's mitre," to receive the tapered and laterally wedge-shaped end of the lower joint. The joints of the rachides are not cylindrical, but narrowed upwards with a sigmoid curve at each side, a character likewise not noticed in the books. Filling each of the spaces thus produced there is an intermediate peculiarly-figured cell (these Mr. Archer would denominate "ramification cells") not shown in the books, from which cells take origin not only the ordinary branches, by a complicated formation of preliminary septa, but also from the ultimate subsidiary cells produced therefrom are given off the first cells of a cortical stratum, from which latter, afterwards, emanate, after a peculiar fashion, those curious collateral filaments forming the "plexus" alluded to by Harvey and others, which, indeed, ultimately forms a very "jungle," the nature of which is very difficult to penetrate or follow out. None of these peculiarities seemed to have been investigated by Agardh or Harvey. But in brief and naturally scanty 'Minutes' like these no justice could be done to so complicated structures, and Mr. Archer would have to defer to a more enlarged opportunity an effort to make up some description of them, and of the seeming mode of evolution of the system of ramification, the whole forming a subject which indeed seemed to grow as he proceeded in the investigation, and to take more time to endeavour to follow out than he had at first anticipated.

Microscopical Section of the Liverpool Medical Institution, Session 1874—75.

The *first* meeting of this section was held on the 16th October, 1874, at which Dr. Caton described a new form of microscope which he had had prepared for physiological purposes. He remarked that, as the methods of preserving and preparing tissues and organs for microscopical research were now nearly perfect, the aim of the physiologist was to examine tissues in the living state; but two great obstacles required to be overcome, viz., that, by the instruments at present in use, only mesentery and omentum could be examined, and, further, that great difficulty was experienced in preventing injury from evaporation and from loss of temperature. Having detailed fully Drs. Burdon Sanderson and Stricker's "warm stage," the author proceeded to describe his new instrument. Dr. Caton cuts off the front half of the stage of his microscope, and places immediately under the objective a piece of concave glass heated by a warm chamber. On this glass plate the tissue to be examined is placed. To preserve the natural moisture of the tissue it is floated in a very weak solution of salt. The optical portion of the instrument is made movable, so that during focussing the object examined is not altered in its position. The heating apparatus is a hollow brass box, having a thermometer attached, and, fixed to this box, are two india-rubber tubes, the one carrying water to, and the other from, the stage. The necessary heat is obtained by means of an iron tube heated in a gas flame, and communicating with the stage cavity.

At the *second* meeting of the section, held on January 8th, 1875, Dr. Davidson described the "microscopical characters of the kidney in post-scarlatinal dropsy." Having referred to Prof. Klebs's observation that this pathological process consisted in a proliferation of the epithelial cells in the Malpighian corpuscles, and that some of these cells became fatty while others desquamated, Dr. D. stated that he had seen the Malpighian bodies filled with nuclei, but he did not regard this alteration in structure to be such an one as would give rise to the clinical phenomena so well known to characterise post-scarlatinal dropsy. While the epithelial lining of the convoluted tubes was observed to be not much altered, a most striking manifestation was the large amount of exudation (granular matter) to be seen in the convoluted tubes. It is the blocking up of the excretory ducts of the organ which the author regarded as explaining best the symptoms of the disease. The various characters of this pathological process were well illustrated by specimens exhibited.

At the *third* meeting of the section, held on February 26th, Mr. R. Parker read his "Supplementary Note on the Mammary Gland, with an account of the Salivary Glands and Pancreas, compared together." After describing the anatomical resemblances and differences in these three organs, Mr. Parker drew attention to the fact that it is only during parturition and lactation that the mamma is an actual secreting gland, while at other times it is latent, though ready to assume active functions. Having described the microscopical characters of the mammary gland before, during, and after its period of activity, Mr. Parker proceeded to detail the varieties of cancerous growth affecting this organ, and which for the most part commence in the terminal acini. He drew attention to the three varieties of carcinoma, viz., "acinose" and "tubular" (which are the most usual forms of this disease), and the less common variety "true scirrhus, or shrinking cancer." The two first have their seat in the secreting acini of the gland; of which, indeed, they are clearly abnormal overgrowths, differing in a manner implied by their names. The initial seat of the last kind is a matter of dispute, but is probably rightly referred to the lymphatic endothelium of the organ. While in acinose cancer the morbid growth proceeds centrifugally, in tubular cancer the disease worms its way in tortuous, tubular tracks. The author's remarks were illustrated by a beautifully complete series of specimens.

The *fourth* meeting of the section was held on 9th April, 1875. Dr. Davidson gave a brief account of "Brown induration of the lungs from chronic congestion, in heart disease." Where there is impeded circulation, especially that resulting from mitral contraction, there results over-distension of the capillaries. Next follows structural alteration of the capillaries, from their becoming tortuous, and from varicosities or dilatations being formed. The amount of interstitial tissue is next increased, and the alveolar walls are thickened. Lastly, there is an escape of leucocytes and of red corpuscles, and these latter, being absorbed, leave behind pigment deposits in the walls of the alveoli, and in the interior of the alveolar epithelial cells, while the alveoli themselves become filled with epithelial cells. These remarks were well illustrated by specimens exhibited.

Mr. M. Harris next drew attention to the head of a Tænia echinococcus which he showed, and which had been bred in the duodenum of a dog.

The *fifth* meeting of this Section was held on the 23rd April; at which Mr. Newton read a paper "On the Origin and Modes of Causation of Infective and Contagious Diseases." After alluding to the interest of this subject to microscopists, seeing the microscope is appealed to by all the parties in this controversy, it was pointed out that several distinct modes of causation may be at work. One, the result of a specific poison, originated we know not how, existing only in consequence of a sort of propagation of species by transmission from person to person, and never now produced otherwise; as smallpox, scarlet fever, syphilis. A second, through poisons produced *de novo*, dependent on or coincident with putrefactive changes in organic matter, either animal or vegetable; as in typhus, typhoid, and puerperal fevers. A third may result from some atmospheric condition superadded to the preceding, as influenza. But the conditions necessary for the spread of one class favour the progress of the others. The relative intensity and striking distance of these poisons vary greatly, many requiring personal contact, as syphilis, others being propagable for some yards through the air only. And even a rag which has been applied to the body of the patient may prove a carrier, months afterwards, in the case of some diseases. The analogy to ferments is very striking, so that Dr. Farr ventured to name the whole class zymotics, or ferment diseases. Animated particles allied to the yeast-plant have been seen by the microscope in all putrescent animal fluids. These have received various names: Bacterium, Micrococcus, Vibrio, Spirilla, and have been supposed to be the cause as well as the mode of transmission of all contagious diseases. It appears to have been certainly proved that the active agent or "contagium," as it is styled by Dr. Sanderson, exists, not in solution, but as minute particles. Yet this is no proof that the particles are bacteria, or, indeed, living matter at all. Besides, it has been shown that all these minute forms of life will live and increase in inorganic fluids, not containing a trace of animal matter. We may, therefore, infer that when bacteria are developed in animal fluids, they derive their carbon and nitrogen, not from the albuminous compounds themselves, but from the ultimate products of their disintegration. They are then not the cause of disease but among the results or accidents of it, and merely associated with a certain stage in the putrefactive process. Their presence in great numbers in any part or fluid may be taken as an indication of septic change, but nothing has yet been done to prove that they have anything to do in originating that change, any more than the maggots in stinking meat have been the cause of its putrefaction. The Bacterium theory of contagion is perseveringly advocated by Dr. Sanderson, and others must therefore be set aside. Dr. Lionel Beale maintains that all communicable diseases are propagated by admission into the body of particles of living matter which have been originally derived by descent from the normal protoplasm of the body, but had grown and multiplied under special and exceptional conditions, and have thus assumed specific contagious characters, forming what Dr. Beale calls "contagious bioplasts." These germs, he says, will retain their vitality for long periods of time, and yet, if they gain access to an appropriate soil, will grow and multiply rapidly. But what proof has he yet given that living matter taken out of the living human body will retain its vitality even for one day or one hour? Dr. Beale has furnished none. It is nothing to the purpose to say that many low forms of life in certain states will retain their vitality for a length of time, even when dried up. These were entire organisms. They were not mere particles of tissues, taken from a highly complex organism. His theory, therefore, is found wanting at the very outset. Mr. Newton next gave a full account of Mr. Davaine's experiments, and others, which showed that, by injecting blood in certain stages of putrefaction into the cellular tissue of animals a disease is produced capable of being transmitted to others in an unlimited series by inoculation of the fresh blood of the animals affected; the disease induced continually increasing in severity, so that in the twenty-fifth series one millionth of a drop of blood sufficed to kill. The blood from typhus and typhoid patients had a similar effect. The symptoms induced were compared with those observed in cases of pyæmia, puerperal fever, erysipelas, &c., and it was maintained that *the poison of zymotic diseases consists of particles of animal matter in a state of unstable equilibrium, verging on putrefaction, which, if introduced into a living body, especially one in a low state of vitality, may induce similar changes to those of the body from which it was derived.*

INDEX TO JOURNAL

VOL. XV, NEW SERIES.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.

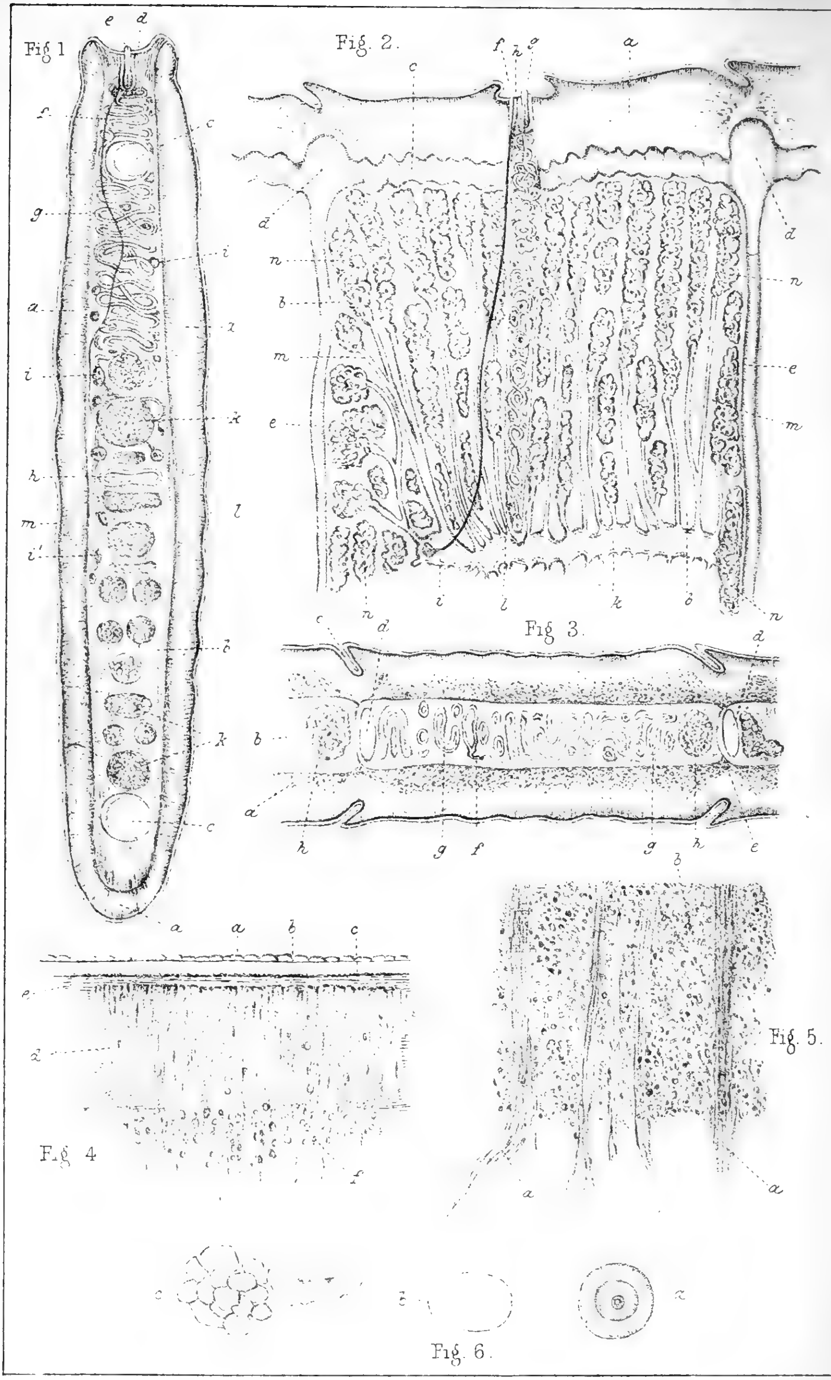
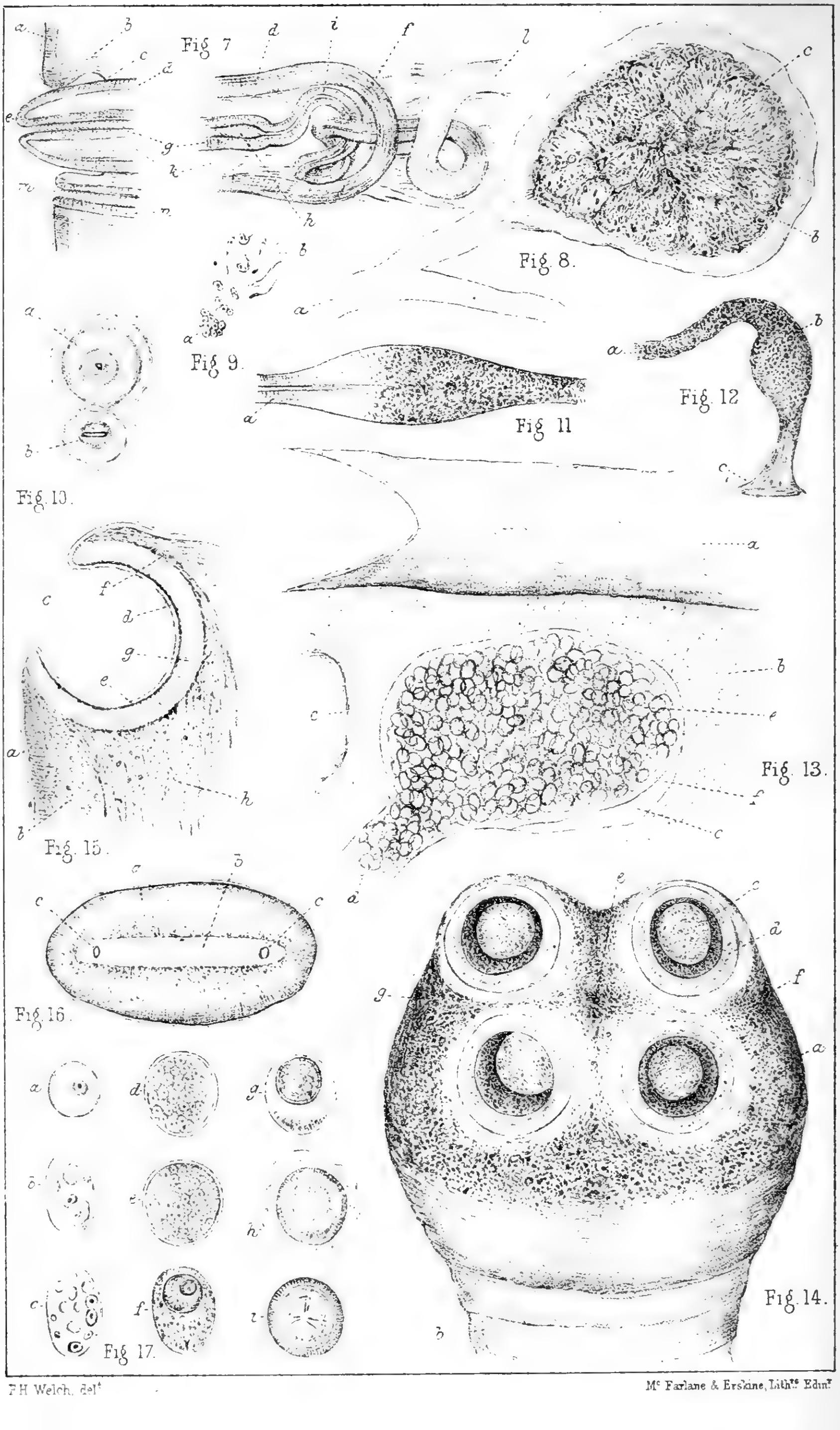


Fig 1
Fig. 2.
Fig 3.
Fig 4
Fig. 5.
Fig. 6.



F. H. Welch, del[t]

McFarlane & Erskine, Lith[rs] Edin[r]

EXPLANATION OF PLATES I & II,

Illustrating Mr. Francis H. Welch's Observations on the Anatomy of *Tænia mediocanellata.*

PLATE I.

FIG. 1 × 10 diameters. Transverse section of an adult segment carried through the genital pit.

a, body structure; *b*, visceral space; *c*, longitudinal water-vascular canals; *d*, genital pit; *e*, penis slightly protruded; *f*, vagina; *g*, seminal duct; *h*, uterus; *i*, seminal glands; *k*, ovarian glands. From the position of the genital ducts to the water-vascular system (*l*) a dorsal and (*m*) ventral surface of the segment can be formed.

FIG. 2 × 10 diameters. Longitudinal section of one half of an adult segment. (For natural reading of figs. 2 and 2 turn the plate sideways with fig. 2 to left hand.)

a, body structure; *b*, visceral substance; *c*, longitudinal water-vascular canal; *d*, bulbous expansion of the canal at its junction with the transverse branch, *e*; *f*, genital pit; *g*, penis; *h*, vagina; *i*, junction of vagina with uterus; *k*, uterus; *l*, fibrous sheath enclosing seminal duct and glands; *m*, ovarian ducts; *n*, ovarian glands.

FIG. 3 × 10 diameters. Vertical section of an adult segment and portions of the contiguous ones, carried through the centre of the zooid.

a, body structure; *b*, visceral space; *c*, inflexion of the body structure at the junction of segments, there the calcareous particles are in a minority; *d*, lumen of the transverse water-vascular canal; *e*, fibrous diaphragm beneath it; *f*, junction of vagina with uterus towards a flat surface of the zooid, that surface ventral; *g*, projections of the uterine canal encroached on by the knife in section; *h*, ovarian glands.

FIG. 4 × 140 diameters. Transverse section of the skin and body structure.

a, epidermis; *b*, corium; *c*, granular layer; *d*, circular muscular bands; *e*, portion of the circular coat not encroached on by the transverse bands (*f*), which have between them calcareous particles.

FIG. 5 × 140 diameters. Longitudinal section of the body structure.

a, bands of longitudinal muscular fibre; *b*, parenchyma with calcareous particles.

FIG. 6 × 500 diameters. Inorganic accretions, "calcareous corpuscles."

a, concentric laminated nodules of carbonate of lime; *b*, homogeneous nodules, some lime carbonate, some fat; *c*, irregular crystals in masses, phosphatic.

PLATE II.

FIG. 7 × 140 diameters. Longitudinal section of penis, the tip and bulb are shown, the intermediate part left out, as requiring too much space for delineation.

a, skin of genital pit and muscular layers of body: *b*, inflexion of fibres which assist in forming a sheath; *c*, depth of preputial inflexion; *d*, external cylinder inflected at the tip (*e*), and forming the bulb (*f*); *g*, internal cylinder, lined by ciliated epithelium; the canal is purposely dilated in the sketch, to render the ciliæ apparent; *h*, internal bulb; *i*, convoluted tube; *k*, longitudinal muscular bands between the cylinders; *l*, seminal duct; *m*, vaginal aperture; *n*, muscular part of vagina lined by ciliæ. Similar remarks apply to this canal as to that of the penis.

FIG. 8 × 225 diameters. Section of a seminal gland, testicular body.
a, seminal duct with a branch passing off to a contiguous gland; *b*, capsule of the gland formed by the expanded duct; *c*, gland substance divided into irregularly shaped masses.

FIG. 9 × 500 diameters. Components of the gland substance.
a, spermatozoa amassed together; *b*, free, and showing the filamentary appendage.

FIG. 10 × 140 diameters. Vertical section of the generative passages just at the genital pit, to show the relation of one to the other.
a, penis; *b*, vagina with the central canal oval.

FIG. 11 × 140 diameters. Longitudinal section of the vaginal bulb near the external orifice.
a, muscular portion merging into the thin walls of the canal generally. The dilatation is seen to be partially studded with pigmental granules.

Fig. 12 × 140 diameters. Vagina near its termination in uterus.
a, aspect of the canal generally; *b*, bulbous expansion near uterus; *c*, merging of the vaginal wall into that of the uterus.

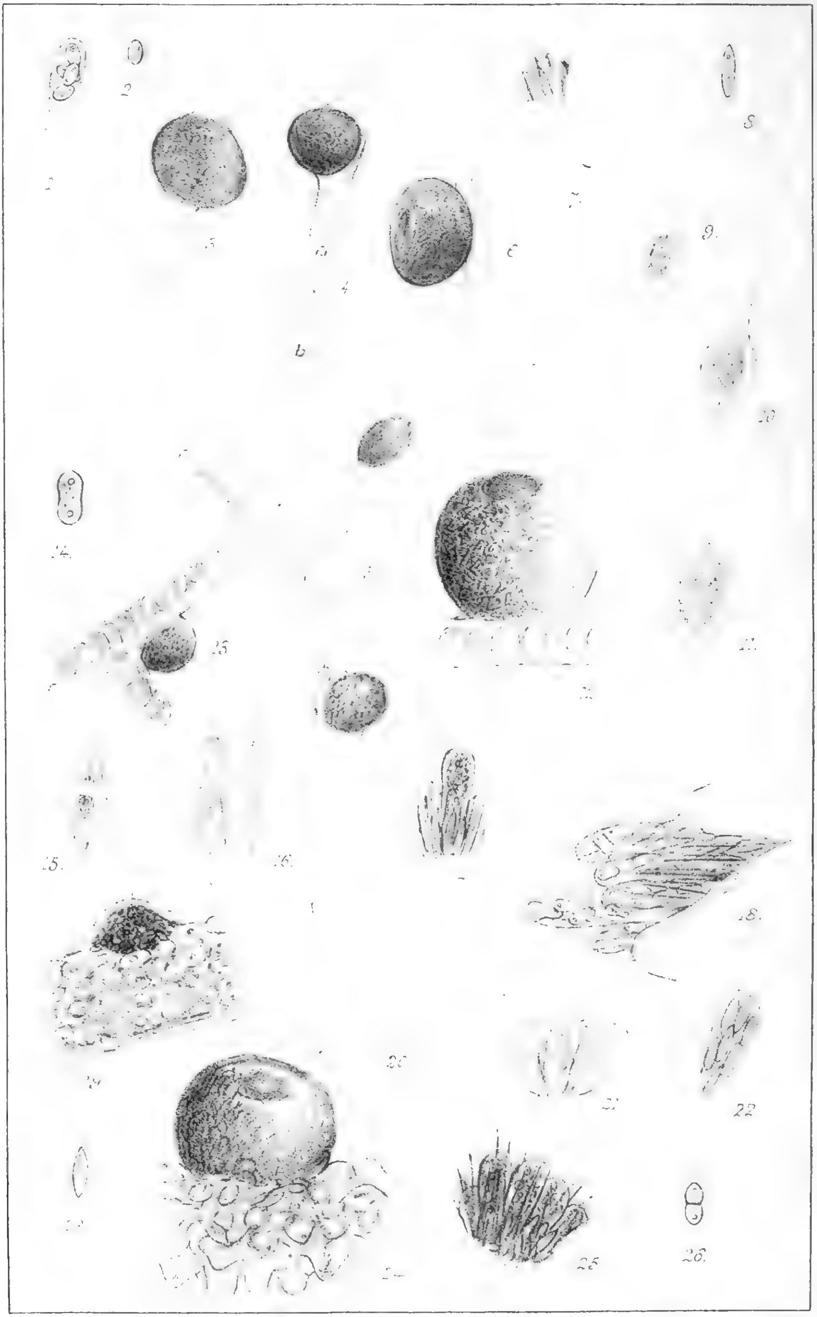
FIG. 13 × 225 diameters. Longitudinal section of a part of an immature segment, adjacent to the transverse canal, and embracing an ovarian gland which is small and has undergone no compression, either from within or without.
a, transverse water-vascular canal; *b*, visceral substance of a granular albuminoid nature; *c*, excavation in it, in which the ovarian gland lies; *d*, ovarian duct; *e*, gland substance made up of amassed nucleated protoplasmic particles; *f*, fibrous tissue wall of gland.

FIG. 14 × 20 diameters. Anterior extremity of the tapeworm colony, the head and four suckers; to bring all the suckers into view, the head (*a*) has been bent upon the neck (*b*); *c*, cuticular lining of the sucker deeply pigmented; *d*, fibrous envelope enclosing the special muscles; *e*, depression in the centre of the head, corresponding superficially to the position of nerve-ganglion (?); from *f* to *g* is the course of the main water-vascular canal of the head, and also the line of junction of the fibrous layer between the dorsal and ventral pairs of suckers.

FIG. 15 × 30 diameters. Vertical section through a sucker.
a, cuticular surface of the body generally; *b*, internal body-structure; *c*, circular orifice of the sucker; *d*, cuticular lining from the external cuticle; *e*, deep layer of corium strongly pigmented; *f*, fibrous envelope; *g*, special muscles, radiating and circular; *h*, longitudinal muscles of the colony inserted into the convexity of the fibrous envelope.

FIG. 16 × 20 diameters. Transverse section through the neck of the colony.
a, body-structure with inorganic nodules and muscular layers similar to the adult zooid; *b*, visceral space containing granular albuminoid material in which the viscera are developed; *c*, longitudinal water-vascular canals.

FIG. 17 × 225 diameters. Ova in different stages of development.
a, earliest—a soft protoplasmic mass with nucleus and nucleolus; *b*, divided nucleus and fat-globules in the protoplasm; *c*, further advanced; *d*, a spherical double-walled flexible body, with nucleus greatly segmented; *e*, segmentation complete; *f*, separation of the components into future egg and granular surroundings; *g*, egg with radiating lines on the shell and enclosed embryo, granular particles collected into a mass; *h*, egg-shell lightly coloured, but completely formed, external protoplasmic mass is irregular and soft, disintegrating; *i*, egg freed from surrounding mass and mature, shell dark brown, with radiating small depressions, inner membrane loosely retaining the soft embryo armed with the six spikelets in pairs.



W. Archer, del.

McFarlane & Erskine, Lith^{rs} Edin^{r}

JOURNAL OF MICROSCOPICAL SCIENCE.

DESCRIPTION OF PLATE III,

Illustrating Mr. Archer's Paper on Apothecia in some *Scytonemaceæ* and *Sirosiphonaceæ*.

From *Scytonema myochrous.*

Fig. 1.—Ascus with 4 spores.
2.—Single spore × 400.

From an unidentified *Scytonema.*

3, 4, 5.—Apothecia.
6.—Mature apothecium.
7.—Same (in ouline) burst, to show protruding asci and paraphyses.
8.—Spore × 400.
9—11.—Showing internal agglomeration of brownish-coloured granules causing swellings of the filaments (incipient apothecia ?).

From *Sirosiphon alpinus.*

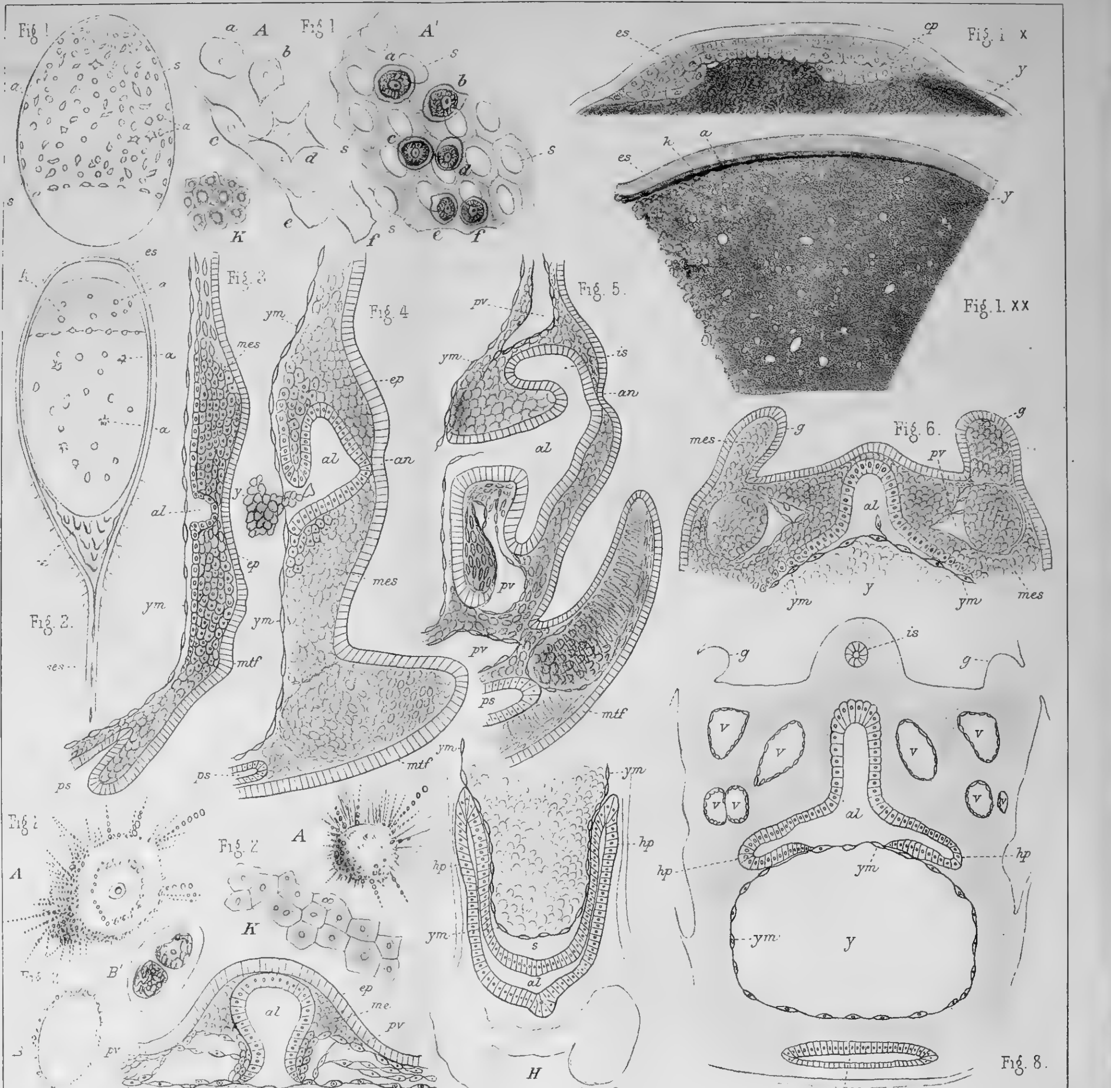
12.—Fully formed apothecium.
13.—Younger apothecium.
14.—Spore × 400.
15.—Ascus, immature, with paraphyses, showing contents contracted into a fusiform figure and divided transversely.
16, 17.—Immature asci with paraphyses.
18.—Showing portion of an apothecium burst so as to cause the 8-spored asci, with paraphyses, to become extruded (the rent portion of the apothecium not shaded).

From *Sirosiphon pulvinatus* or *S. Heufleri.*

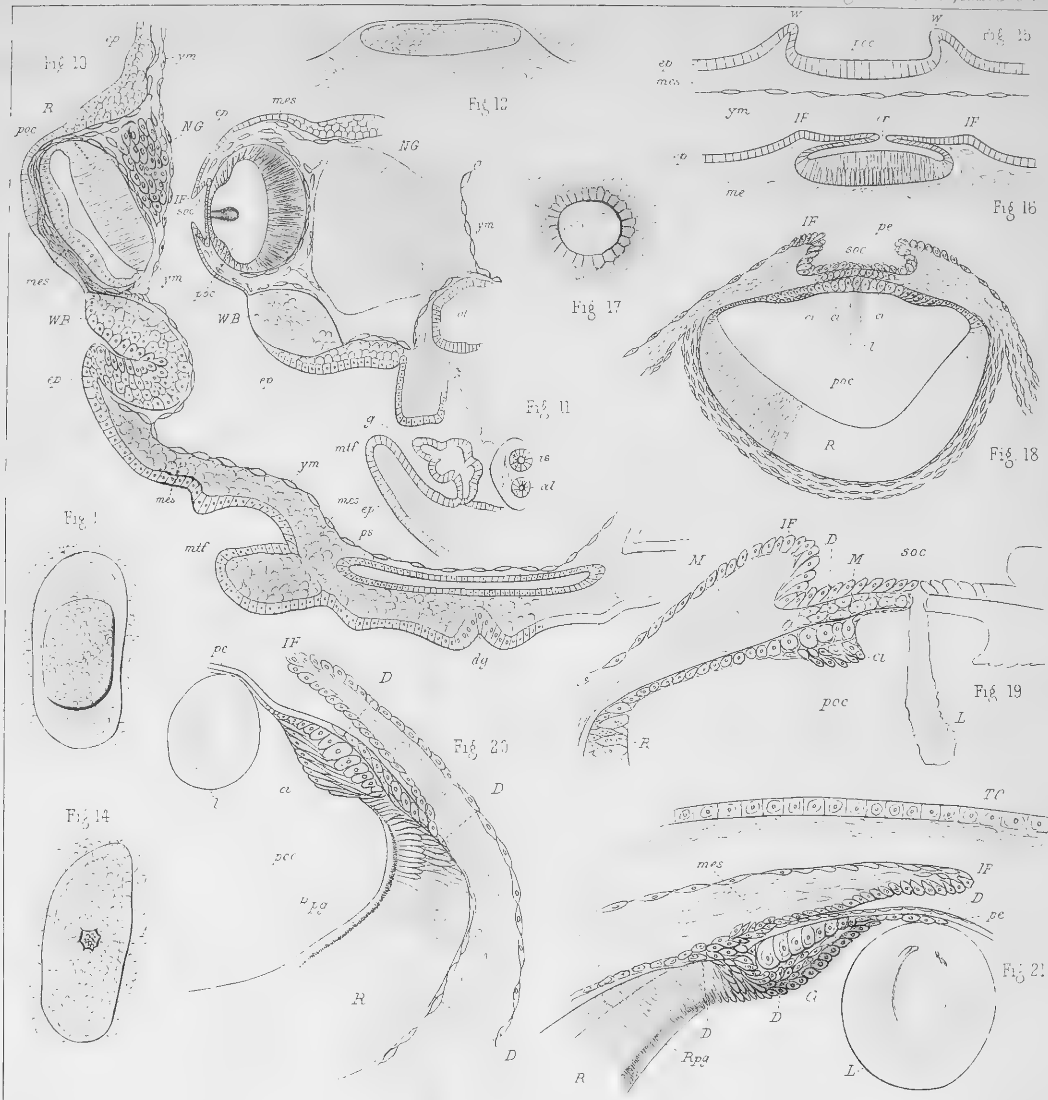
19.—Immature apothecium.
20.—Outline of mature apothecium.
21.—Immature asci.
22.—Mature ascus with 8 spores.
23.—Spore × 400.

From *Stigonema mamillosum.*

24.—Apothecium.
25.—Immature asci with paraphyses.
26.—Spore × 400.



Mc Farlane & Erskine, Lithrs Edinr



McFarlane & Erskine, Lith^rs Edin^r

EXPLANATION OF PLATES IV and V,

Illustrating Mr. Ray Lankester's Observations on the Development of the Cephalopoda.

N.B.—The figures are *not* drawn to one scale.

Fig. 1.—Egg of *Loligo* represented without its coverings; the blastoderm has spread over four fifths of the egg's surface. The autoplasts (*a*) are seen through the transparent klastoplasts, which only appear in optical section as the layer *s*.

Fig. 1 a.—Six autoplasts from the yelk-sac-pole of a *Loligo's* egg, in which the blastoderm has nearly involved the whole surface. The same autoplasts are seen in Fig. 1 a′ after the addition of dilute acetic acid. This has brought into view the superficial and large klastoplasts, *s s*, and has granulated and contracted the subjacent autoplasts.

Fig. 1 k.—Klastoplasts from the surface of the specimen drawn in fig. 1.

Fig. 1*.—Vertical section through the cleavage area of a *Loligo's* egg, hardened in osmic acid. The annular peripheral thickening of the mass of cleavage-cells is seen in section: also observe the thinning out of the cleavage patch at its extreme periphery. *es.* The horny egg-shell. *cp.* Cleavage products. *y.* Yelk.

Fig. 1**.—Portion of a section of an egg of the same stage as that seen in Fig. 1 hardened in osmic acid. The long axis of the egg runs right and left in this section, the cleavage pole being towards the left. A portion of the blastoderm is seen in section, and a large mass of yelk; *es*, as before, is the egg-shell. Below we have *k* the klastoplasts and a deeply stained layer; below that *a*, which appears to consist of autoplasts. The light spaces in the yelk may represent merely vacuoles, but are more probably the points occupied by gradually differentiating autoplasts.

Fig. 2.—Egg of *Octopus* in its horny shell (*es*), which has a stalk (*ses*) four times the length of the egg-shell itself. The shaded part (*k*) indicates the gradually extending cap of klastoplasts; *aa* are autoplasts. *ce.* The embossed "capsular envelope" of the egg—a delicate pellicle which the egg derives from the inner stratum of the ovarian capsule—and which in *Octopus, as also in Loligo*, may be seen thrown off in delicate shreds when the first ciliary movements commence.

N.B.—In *Octopus*, as soon as the blastoderm is complete, the egg *reverses its position* in the egg-shell, the cleavage pole taking up its position nearest the egg-stalk, whilst the yelk-sac-pole occupies the opposite end of the chamber. This total reversal of position also takes place in *Argonauta*.

Fig. 2 a.—*A.* Deep-lying autoplasts from the egg of *Octopus*, showing radiating lines of granules as in the formation of nuclei described by Oellacher and by Fleming. *B.* A pellucid autoplast; *B′* its appearance after dilute acetic acid. *K.* Klastoplasts from the cap *k* of fig. 2.

Fig. 3.—Part of a vertical antero-posterior section of a *Loligo* embryo hardened in picric acid and absolute alcohol (Kleinenberg's method). *ep.* Epiblast. *mes.* Mesoblast. *ym.* Deepest layer of embryonic cells covering in the yelk, and hence to be called *yelk epithelium*. *al.* Lumen of alimentary canal (aboral portion). *ps.* Pen sac, still open. *mtf.* Edge of the mantle.

Fig. 4.—A similar section of an older embryo. *y.* Yelk. *an.* Anal depression of the epiblast. Other letters as in fig. 3.

Fig. 5.—A similar section of a yet older embryo. *pv.* Primitive vascular spaces in the mesoblast. *is.* The rudiment of the ink-sac

becoming marked off from the alimentary cavity. Other letters as in figs. 4 and 5.

Fig. 6.—Part of a transverse section of an embryo of the same age as that illustrated in fig. 4. The section passes through the rudiments of the two gills, *g g*. Other letters as in figs. 3, 4, 5.

Fig. 7.—Part of another transverse section from the same specimen. Letters as in the preceding figures.

Fig. 8.—The central portion of a transverse section of an embryo about the same age as that of fig. 5. *is.* Extremity of ink-sac. *g.* Root of gill. *vv.* Vascular spaces. *f.* Space filled with food-yelks. *ym.* Yelk epithelium. *hp.* Hepatic diverticula of the alimentary canal, *a l.*

Fig. 9.—Part of a right and left longitudinal section of a similar embryo. *H.* Part of the circulatory organs. *S.* Space left between the yelk-epithelium and the intestinal epithelium, due to the contraction caused by the hardening reagents. Other letters as in preceding figures.

Fig. 10.—Left side of a longitudinal right and left section of an embryo *Loligo* of the same age as that of fig. 4. *ym.* Yelk-epithelium. *mes.* Mesoblast. *ep.* Epiblast. *NG.* Nerve-ganglion. *R.* Retina. *poc.* Primitive optic chamber. *WB.* White body. *mtf.* Mantle-flap or free margin. *ps.* Pen-sac. *dg.* Median groove, indicating the line of closure of the lips of the pen-sac.

Fig. 11.—A similar section of a much more advanced embryo. *ep.* Epiblast. *mes.* Mesoblast. *ym.* Yelk epithelium. *NG.* Nerve-ganglion. *WB.* White body. *poc.* Primitive optic chamber. *soc.* Secondary optic chamber. *IF.* Iridean folds. *ot.* Otocyst. *g.* Gill. *is.* Ink-sac. *al.* Alimentary canal (rectum). *mtf.* mantle-flap.

Fig. 12.—Side view of eye-rudiment in a specimen of same age as that of fig. 3.

Fig. 13.—View of same from above.

Fig. 14.—Similar view of a somewhat later condition.

Fig. 15.—Diagrammatic vertical section of fig. 13. *ep.* Epiblast. *mes.* Mesoblast. *ym.* Yelk epithelium. *W.* Wall of the primitive optic chamber, *poc.*

Fig. 16.—Similar section of fig. 14. *IF.* Commencing iridean fold. *or.* Orifice of invagination of the primitive optic chamber not quite closed.

Fig. 17.—Primitive condition of the otocyst as an open pit or invagination of the epiblast.

Fig. 18.—Section of the eye in a more advanced state (from preparation preserved in Canada balsam). The drawing in this case does not give a section passing through the central point of the eye, but one a little above it. *IF.* Iridean fold. *pe.* Posterior wall of the secondary optic chamber, *soc.* *poc.* Primitive optic chamber. *ci.* Ciliary body. *l.* Lens. *R.* Retina.

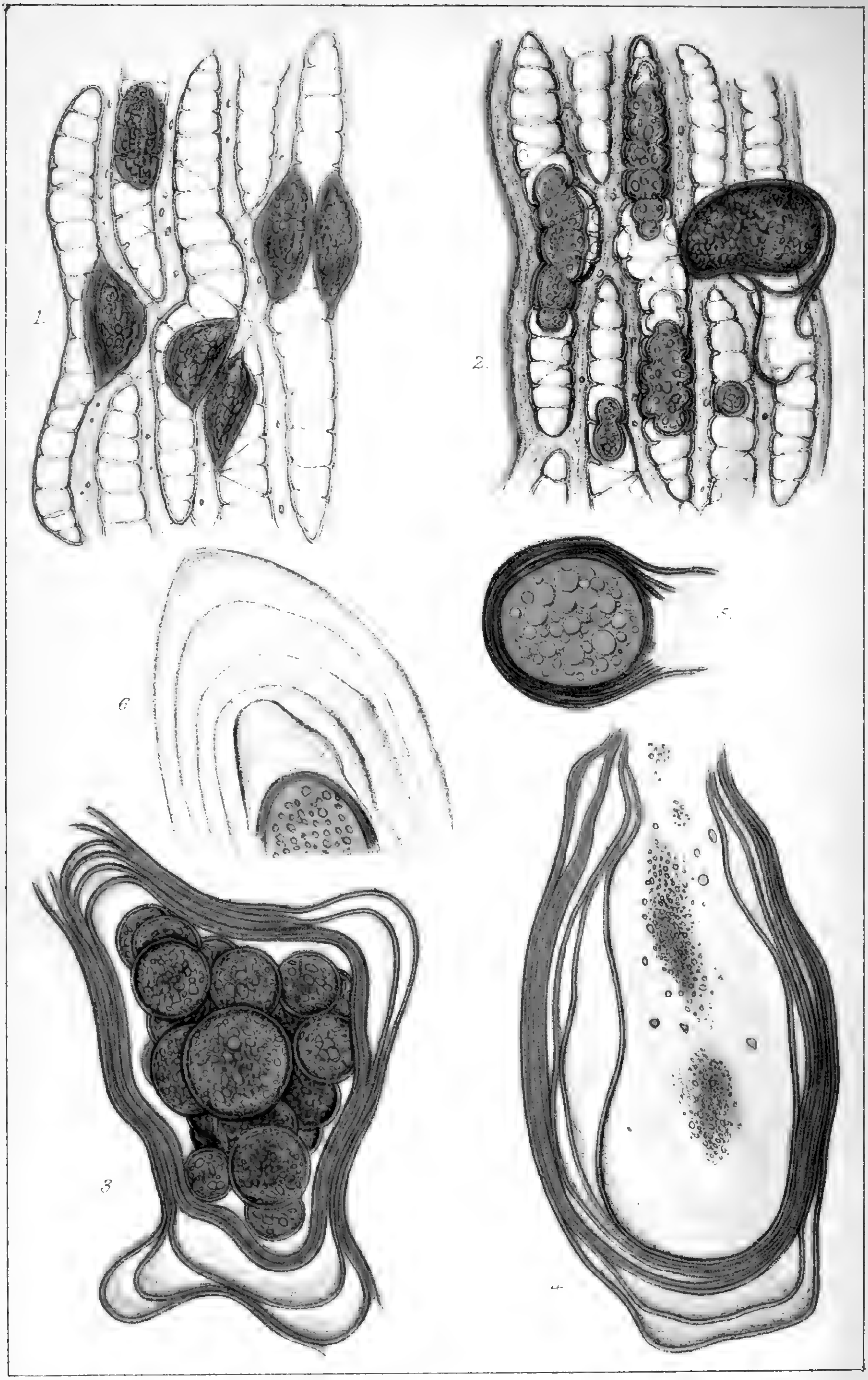
Fig. 19.—Actual median section of the front part of the same specimen, more highly magnified. *D.* Line of demarcation between the epiblastic cell-lining of the primitive optic chamber and its mesoblastic investment, *M.* *L.* Lens. *R.* Retina. *ci.* Ciliary body. *soc.* Secondary optic chamber. *poc.* Primitive optic chamber. *IF.* Iridean fold.

Fig. 20.—Median section of a part of the eye of a more advanced embryo. *RPg.* Retinal pigment. Other letters as in figs. 18 and 19.

Fig. 21.—A similar section from an embryo nearly r[illegible] to leave the egg-shell. *TO.* Tegumentary overgrowth, which [illegible]e so-called "cornea" (never completely closed in the middle p[illegible]y Cephalopoda) and completes the secondary optic chamber. [illegible]tters as in preceding figures.

G. Pertier del.

McFarlane & Erskine Lithrs Edinr



W. Archer, del[t]

McFarlane & Erskine, Lith[rs] Edin[r]

DESCRIPTION OF PLATES VI & VII,

Illustrating Mr. Archer's Paper on *Chlamydomyxa labyrinthuloides*, n. g. et sp.

PLATE VI.

Plate VI represents an entire example, the body-mass having become extruded through the torn-like opening in the many-layered outer envelope, and showing the greenish, reddish, and bluish-colouring granules, pulsating vacuoles, and some incepted foreign bodies. Far extending in a tortuous reticulated "labyrinth" are seen the *filamentary tracks* (Fadenbahn, Cienkowski) with numbers of the bluish granules travelling thereon, now becoming fusiform in figure (*Spindles*). Towards the left of the example, in an outlying portion of the mass is seen a vacuole showing a temporary cleft or rift in the substance at each side of it. Towards the right is seen a nearly isolated *colony* of the mass containing a digested example of *Oocystis Naegelii*. At the further extremity occur two similar nearly isolated portions, one showing embedded an as yet undigested example of *Spirotænia gracillima* (n. s.), all these outlying portions showing some vacuoles. Towards the left of the figure a small portion of the body-mass has become on some former occasion independently re-encysted, and is now "dormant." × 400 Diam.

PLATE VII.

Fig. 1 shows certain bodies found in the cells of the Sphagnum plant occurring in the same pool, and often on the same plants which harbour undoubted examples of this organism (as shown in next figure), and supposed to have some genetic relationship.

Fig. 2.—A portion of a leaf of Sphagnum showing young *Chlamydomyxa* examples; to the left are seen green ones, near the bottom two very small still globular, towards the middle a few now red, owing to the abundance of the red granules; the larger examples have put on a torulose figure, owing to the constriction caused by the recurring cincture of the annular fibre of the Sphagnum-cell. Towards the right is seen a *Chlamydomyxa* extruded, and still attached by a neck-like portion of the wall; the contents have become re-encysted now outside the Sphagnum-cell.

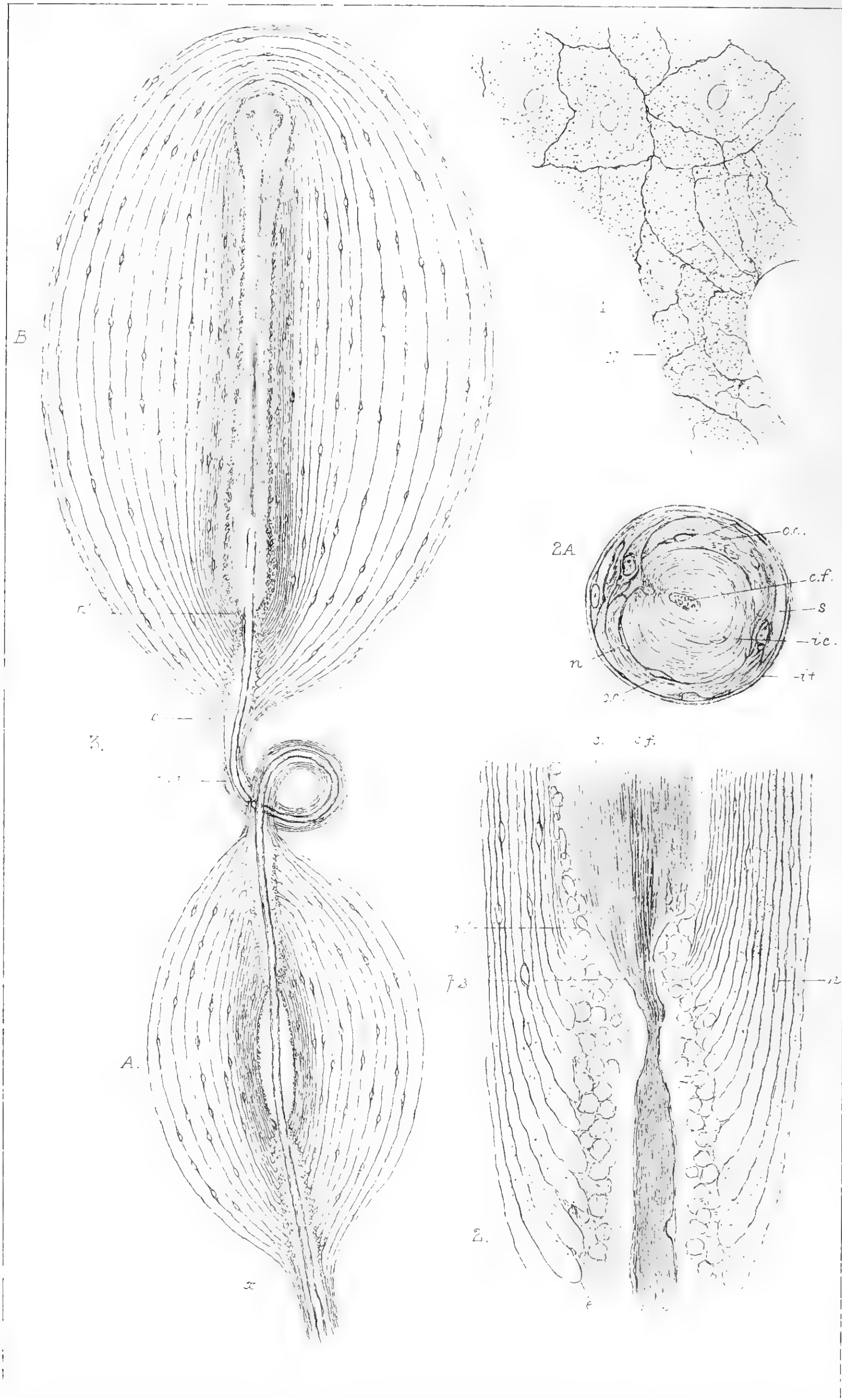
Fig. 3.—A condition rarely met with showing the inner sarcodic substance subdivided in a number of nearly equal-sized globular portions, the contents reddish inclining to orange, and each individual ball encysted in its proper wall; the whole within the outer many-layered original envelope.

Fig. 4.—The many-layered envelope of an example after severe pressure, the most of the substance removed, a few colouring granules only being left.

Fig. 5.—A small example after being boiled in caustic potash.

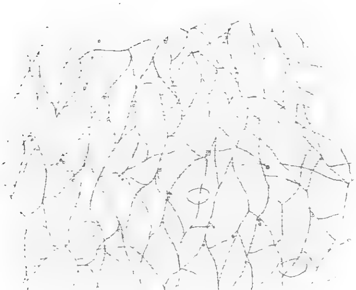
Fig. 6.—Portion of an example treated with iodine and sulphuric acid.

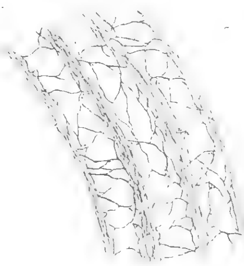
All the figs. × 200 diams.



W. H. Wesley lith. W. West & Co. imp. E. A. Schafer ad nat. del.

4.





W. H. Wesley lith. W. West & Co. imp. E. A. Schäfer, ad nat. del.

EXPLANATION OF PLATES VIII & IX,

Illustrating Mr. Schäfer's paper on the Structure of the Pacinian Corpuscles considered with reference to the Homologies of the several parts composing them.

Fig. 1.—Stalk of a Pacinian corpuscle treated with nitrate of silver, showing the two epithelioid layers of cells belonging to the outermost tunic continuous with those of the corresponding layer of the neurilemma, N, of the nerve.

Fig. 2.—Small portion of a Pacinian corpuscle, showing the mode of entry of the nerve-fibre into the core (osmic acid preparation). *m s*, nerve-fibre, with medullary sheath (stained dark), the primitive sheath is seen on either side; *p s*, primitive sheath of the nerve turning outwards to pass between the inner striated part of the core, *c*, and the outer nucleated part; *c f*, fibrillated axis-cylinder of the nerve-fibre continued into the core as the *central fibre; e*, series of innermost tunics of the corpuscle enlarged at their extremities (the transverse fibres in their interior are seen in section as mere dots); *n*, nuclei between adjacent tunics. Between the ends of these innermost coats of the Pacinian and the nerve fibre is the delicate tissue of the endo-neurium with irregular nuclear bodies similar to and in continuity with those (*n'*) of the outer part of the core.

Fig. 2A.—Core of a Pacinian corpuscle, as seen in transverse section (from an osmic acid preparation); *c f*, central fibre; *i c*, inner part of the core, appearing faintly striated concentrically to the axis except at one place where the outer part (*o c*) of the core encroaches somewhat upon it. This outer part is seen to be made up mainly of delicate nucleated cells; *n*, a flattened nucleus, lying next to the inner core: *i t*, innermost tunic of the corpuscle bounding the core externally; between them a space; *s* (lymphatic?).

Fig. 3.—Two Pacinian corpuscles connected by the nerve-fibre, which is seen passing entirely through the smaller one, A, without loss of its medullary sheath to terminate in the larger one, B, the medullary sheath being also continued a short distance into the core of the latter; *n'*, as in figure 2; *x x*, the outermost tunics of the corpuscle are shown to be continuous

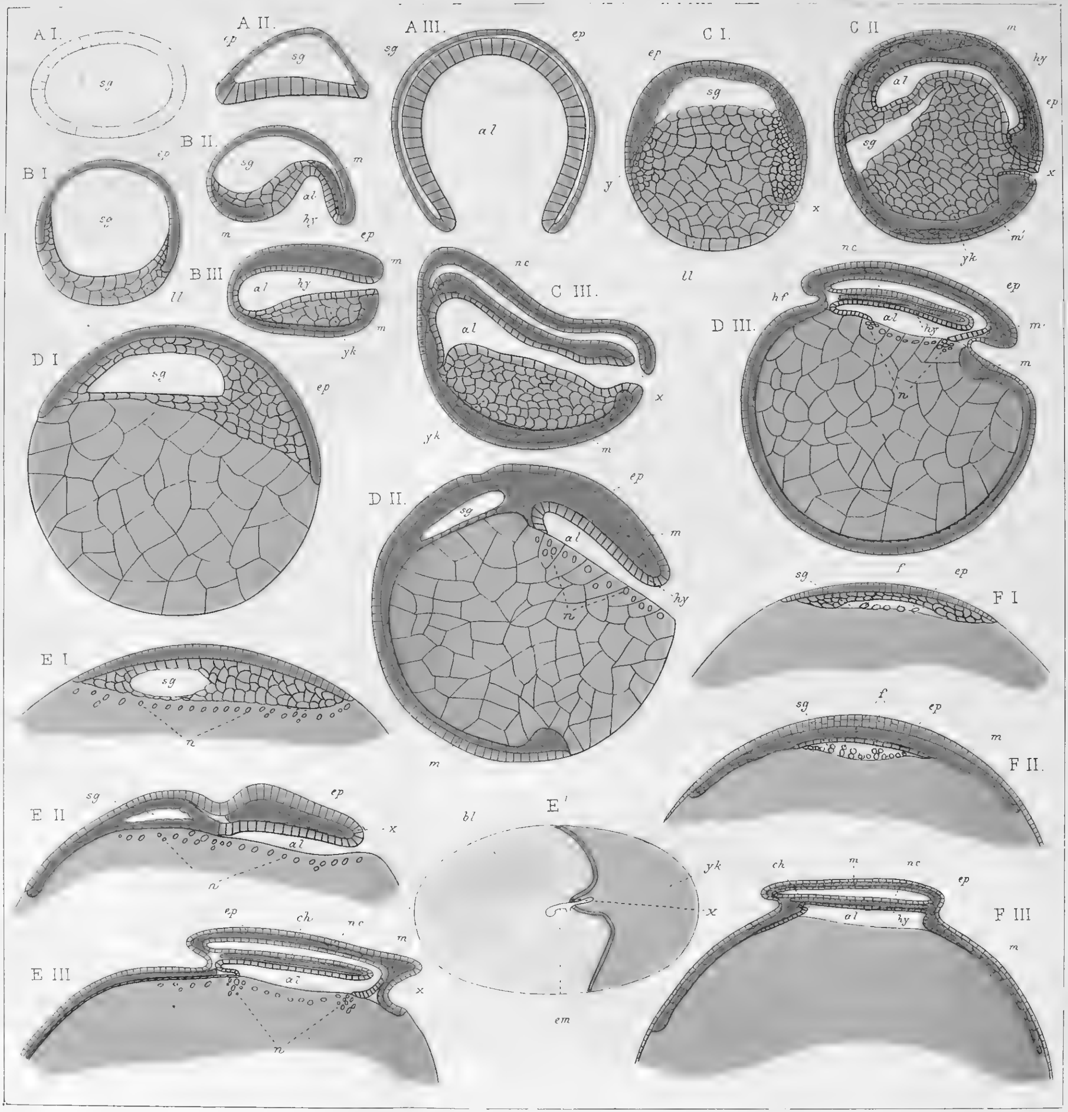
with the corresponding layers of the neurilemma (*n m*) surrounding the nerve-fibre.

Fig. 4.—Transverse section of Pacinian corpuscle (chloride of gold preparation, a portion only is represented); *a a'*, outermost tunics of the corpuscle slightly separated one from another by (artificial) clefts, *b*; *c*, innermost tunics, closely arranged around the core, *d*. At either edge of the outer tunics are seen oval nuclei belonging to the flattened cells which cover their surfaces. (The fibres within the tunics are not rendered visible by this mode of preparation.)

Figs. 5, 6.—Portions of teazed-out preparations (chromic acid one-sixth per cent.). In fig. 5 a portion of three of the tunics is seen as torn off transversely to the axis of the corpuscle; in fig. 6 a surface-view is shown of a portion of a "capsule," so-called. *c*, fine, closely-set fibres, seen in fig. 5, to form a layer on either side of the flattened cells, which bound the tunics, these themselves being less distinctly seen than in the chloride of gold preparation (fig. 4); *e*, reticulating fibres, stretching across the interstitial space of each tunic: the dots represent the broken ends of some of the fibres. In fig. 6 the oval nuclei, *n*, of the layer of epithelioid cells are seen (the cell outlines are not visible); over these the continuous layer of delicate transversely arranged fibres, *c*, and, finally, the more strongly marked reticulating fibres, *e*.

Most of the figures represent the parts very highly magnified, but none are drawn to scale. Figs. 1 and 2 were drawn under a power of about 600 diameters; fig. 2A, of 1000 diameters; fig. 3 of about 200; fig. 4, of about 400; and figs. 5 and 6 under a power of about 800 diameters.

For the high powers Hartnack's immersion lenses were employed.



McFarlane & Erskine, Lith^rs Edin^r

EXPLANATION OF PLATE X,

Illustrating Mr. F. M. Balfour's paper on the Early Stages in the Development of Vertebrates.

Complete List of References.

s g. Segmentation cavity.
al. Cavity of alimentary canal.
ep. Epiblast.
l l. Lower layer cells.
m. Mesoblast.
hy. Hypoblast.
x. Point where epiblast and hypoblast are continuous at the mouth of the alimentary involution. This point is always situated at the tail end of the embryo.
yk. Yolk.
n c. Neural canal.
ch. Notochord.
n. Nuclei of yolk of Selachian egg.
f. Formative cells.
bl. Blastoderm.
em. Embryo.

Epiblast is coloured yellow, mesoblast red, and hypoblast green. The lower layer cells before their separation into hypoblast and mesoblast are also coloured green.

A I, A II, A III.—Diagrammatic sections of Amphioxus in its early stages (founded upon Kowalevsky's observations).

B I, B II, B III.—Diagrammatic longitudinal sections of an hypothetical animal, intermediate between Amphioxus and Batrachians, in its early stages.

C I, C II, C III.—Diagrammatic longitudinal sections of Bombinator igneus in its early stages (founded upon Götte's observations). In C III the neural canal is completed, which was not the case in B III. The epiblast in C III has been diagrammatically represented as a single layer.

D I, D II, D III.—Diagrammatic longitudinal sections of an animal, intermediate between Batrachians and Selachians, in its early stages.

E I, E II, E III.—Diagrammatic longitudinal sections of a Selachian in its early stages.

E′.—Surface view of the yolk of a Selachian's egg to show the manner in which it is enclosed by the Blastoderm. The yolk is represented green and the Blastoderm yellow.

F I, F II, F III.—Diagrammatic longitudinal sections of a Bird in its early stages.

EXPLANATION OF PLATE XI,

Illustrating Dr. John Denis Macdonald's paper on the Anatomy of the Border of the Posterior Elastic Lamina of the Cornea, in Relation to the Fibrous Tissue of the Ligamentum *Iridis Pectinatum.*

Fig. 1 shows a marginal strip of *Descemet's* membrane carefully removed, with the corresponding portion of the *ligamentum iridis pectinatum* from the eye of the sheep. The pectinate bundles in front and the reticulate tissue behind them were well seen in the original preparation.

Fig. 2 represents a similar object, but more highly magnified and focussed superficially so as to bring the marginal tendons, or pillars of the iris, with their hyaline envelopes, more distinctly into view. A deeper focus would reveal the fibrous plexus extending beyond them and in front of the elastic lamina.

Fig. 3 is from the eye of the ox, and exhibits the anterior aspect of a part of the border of *Descemet's* membrane, with the zone of fibrous tissue from which both the pectinate and reticulate fasciculi of the iris take their rise.

The following references are applicable to all the figures:

- *a.* A small strip of the unaltered or optical area of the elastic lamina (seen in front in Fig. 3 only[1]).
- *b.* Pectinate processes of the margin of the iris, composed of delicate wavy fibres, probably contractile.
- *c.* The little tendons of those processes enveloped by—
- *d.* Conical tabular extensions from the posterior surface of the elastic lamina.
- *e.* Nearly rectangular and dichotomous division of the tendons at the anterior surface of the lamina, through which they are seen in Figs. 1 and 2.
- *f.* The inter-communication of the divided tendons.
- *g.* The fibrous structure into which they ultimately break up.
- *h.* Attenuated extension of the membrane of *Descemet* into the outer wall of the canal of *Schlemm.*

[1] It may facilitate the comprehension of the figures if they are each regarded as representing the attachment of a portion of the lower border of the iris with that structure facing the observer.

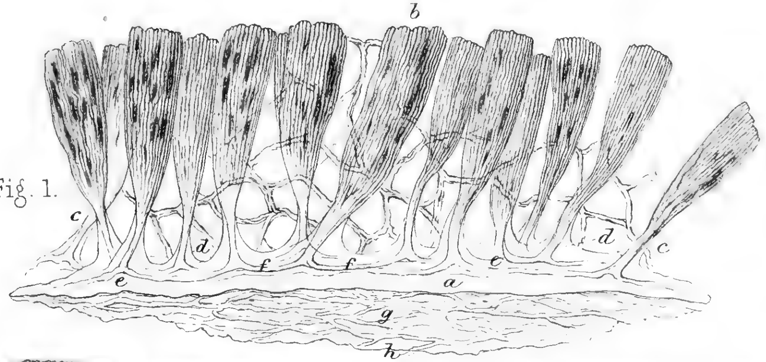


Fig. 1.

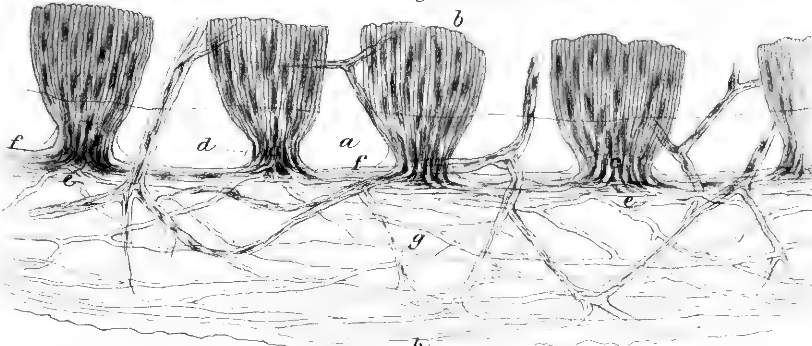
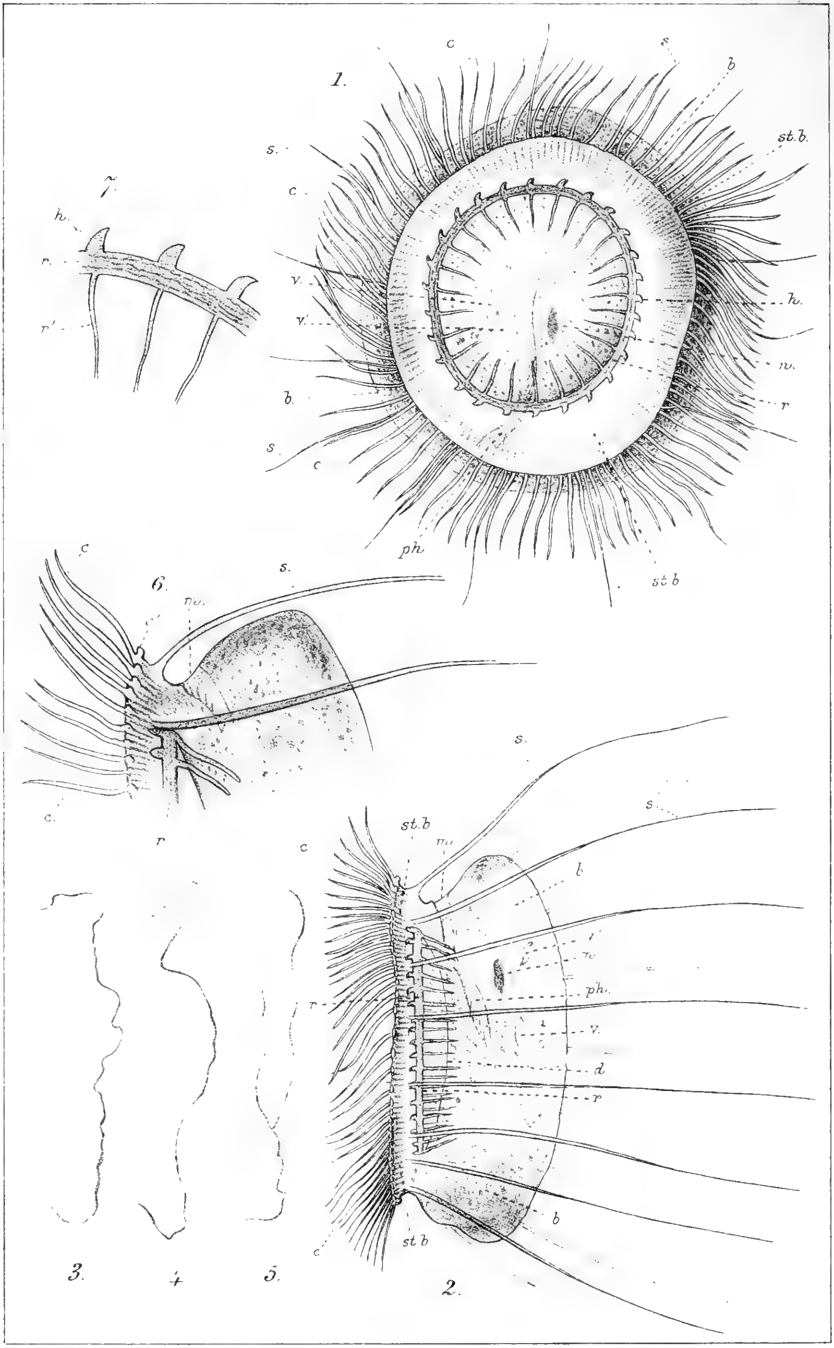


Fig. 3.

Fig. 2.



W. H. J. delt

Mc Farlane & Erskine, Lithrs Edinr

EXPLANATION OF PLATE XII,

Illustrating Mr. Hatchett Jackson's Paper on *Cyclochæta spongillæ.*

FIGS.

1.—Animal with disc turned towards observer.

2.—Side view, showing shape of the body and setæ.

3, 4, 5.—Side view of body, showing successive changes in its shape in one and the same individual.

6.—Enlarged view of upper part of fig. 2.

7.—Ring (a portion) as seen under ocular 4, and object glass 8 (Hartnack) with tube drawn out.

The signification of the letters is the same in all the figures:

c. Motor cilia.
c^1. Nodule at base of each cilium.
s. Setæ.
st. b. Striated border.
r. Hooked ring.
h. Hooks.
r^1. Radii.
d. Outline of central depression.
b. Body.
m. Mouth.
ph. Pharynx.
v. Vacuole, apparently permanent
v^1. Occasionally appearing vacuoles.
n. Endoplast. (nucleus auctt.

JOURNAL OF MICROSCOPICAL SCIENCE.

EXPLANATION OF PLATE XIII,

Figs. 1—5,

Illustrating Mr. T. B. Lewis's paper on Nematode Hæmatozoa in the Dog.

Fig. 1.—Three portions of a mature female *Filaria sanguinolenta* :—

a. Anterior portion, the outline of the mouth altered through separation of the cuticle by the action of spirit.

b. Termination of genital tube; the vagina, twisted on itself, is seen alongside the intestinal canal immediately below the junction of the latter with the œsophagus. It is distended with ova and divides into the two uterine tubes.

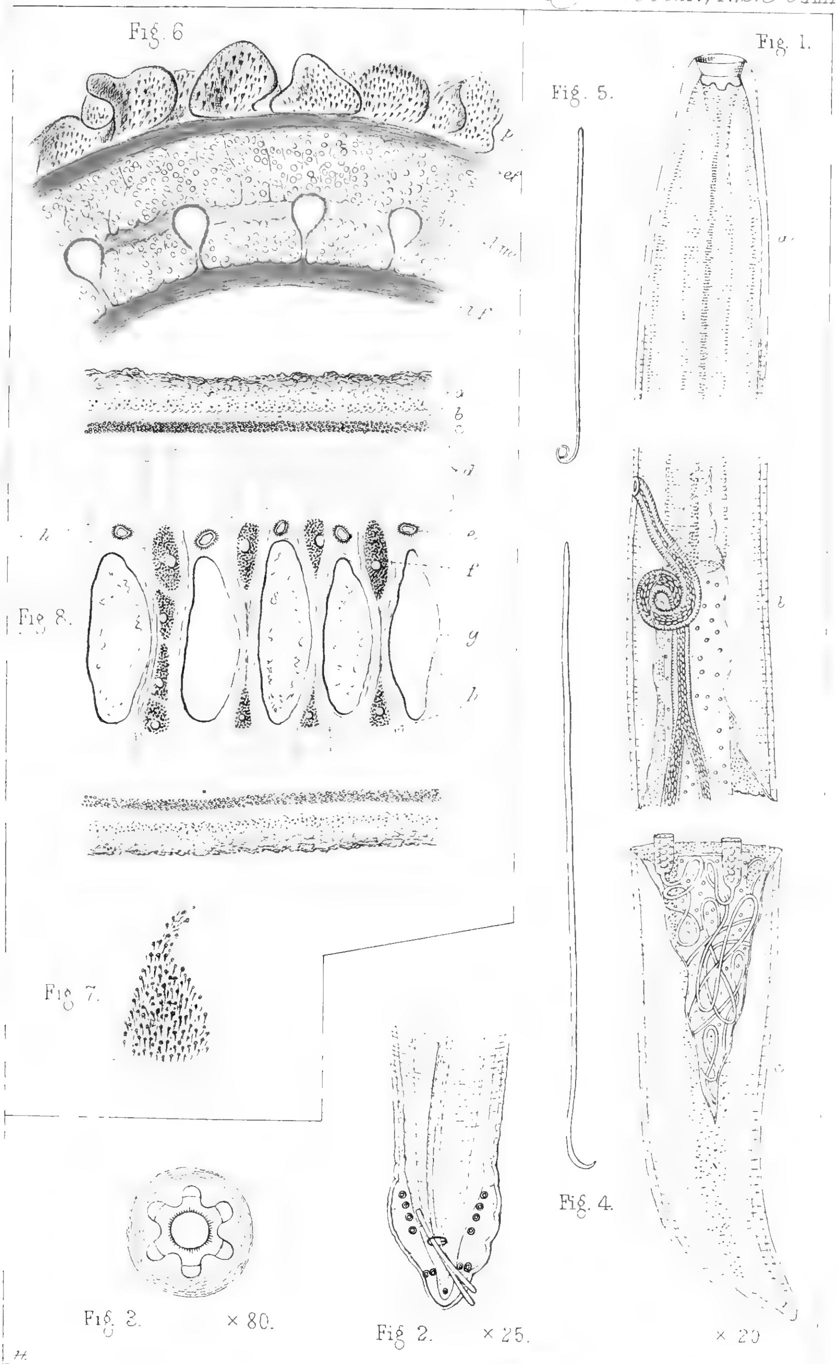
c. Caudal extremity: the two uterine tubes with cellular contents, are observed to terminate abruptly in minute tubules (the ovarian) which form coils around the lower portion of the alimentary canal × 20.

„ 2.—Caudal extremity of the male. Ventral aspect. Two spicules are seen of unequal length, with eight pre-anal and four post-anal papillæ × 25.

„ 3.—The mouth as seen from the front, with its six minute 'lips' and chitinous pharynx × 80.

„ 4.—Mature *Filaria sanguinolenta* found in walls of aorta and œsophagus of pariah dogs in India : *female* natural size.

„ 5.—Ditto, ditto, *male* natural size.



McFarlane & Erskine, Lithrs Edinr

EXPLANATION OF PART OF PLATE XIII.

Figs. 6—8,

Illustrating Dr. A. A. W. Hubrecht's Remarks on the Minute Anatomy of Mediterranean Nemerteans.

Fig. 6.—Segment of a transverse section through the anterior part of the extruded proboscis of a Drepanophorus (n. gen.).

p. The layer of bacillar-papillæ.
e. f. External layer of circular fibres.
i. f. Internal layer of circular fibres.
l. m. Longitudinal muscular layer, supported by a meshwork of fibres which communicate with the circular layers, and enclose the so-called beaded layer (MacIntosh).

Fig. 7.—A separate bacillary papilla from the proboscis of Drepanophorus.

Fig. 8.—Longitudinal tangential section of a Drepanophorus.

a. Cutis carrying the pigment globules.
b. Fibrous basal membrane sending supporting fibres into the cutis-tissue, and others which traverse
c and *d.* The circular and longitudinal muscular layers.
h h. Fibrous dissepiments, being the continuation of those fibres after they have entered the body-cavity. These dissepiments enclose between them the cœcal appendages of the intestine (*g*), and the transverse blood-vessels (*e*). The appearance of the generative products (*f*) is accompanied by a splitting-up of these dissepiments into two distinct plates, which in the normal condition lie close against each other.

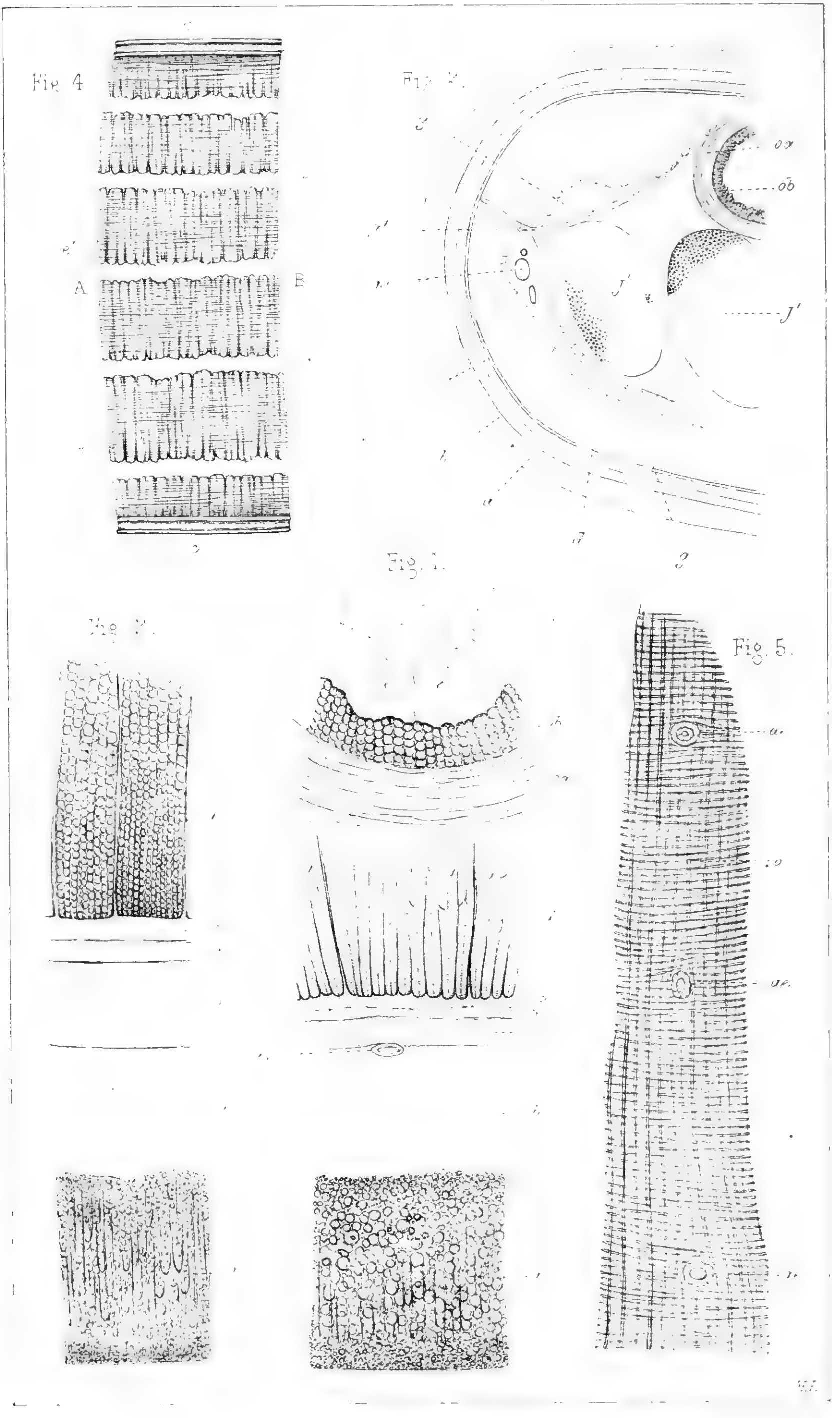


Fig. 4
A
B
oa
ob
Fig. 1.
Fig. 5.
a

EXPLANATION OF PLATES XIV & XV,

Illustrating Dr. M'Intosh's Paper "On *Amphiporus spectabilis* and other Nemerteans."

PLATE XIV.

Fig. 1.—Transverse vertical section[1] through the anterior dorsal region of *Amphiporus spectabilis,* Quatref. (*Drepanophorus rubrostriatus,* Hubrecht). *a,* cutis; *b,* basement layer; *b e,* peculiar median band; *c,* circular muscular coat of the body-wall; *c e,* thin decussating layer; *c o,* thin coat, probably composed for the most part of oblique fibres; *d,* longitudinal muscular layer of the body, showing a somewhat pennate arrangement, and intersected by the radiating fibres into groups of fasciculi. *o a,* external or chiefly circular layer of the proboscidian sheath; *o b,* internal or longitudinal coat of the same; *o c,* mucous layer of the sheath. × 210 diameters.

Fig. 2.—Similar section near the median dorsal region of *Amphiporus hastatus.* The letters as in Fig. 1. The much greater development of the thin layers *c e* and *c o* is conspicuous. The latter has its fibres less oblique than the former (*i. e.* chiefly circular), the cut ends being very evident in longitudinal vertical sections. × 210 diameters.

Fig. 3. Vertical transverse section of the anterior region of *Amphiporus hastatus,* showing the quiescent generative (?) organs *g, g,* in the form of long tubes filled with granular nucleated cells, and meeting at *g′* to pass between the fasciculi of the great longitudinal muscular layer of the body wall. *j′,* the alimentary chamber, only a few of its granules having been indicated; *n,* lateral nerve. Other letters as before. × about 20 diam.

Fig. 4.—View of a portion of the wall of the anterior chamber of the proboscis in *Amphiporus pulcher,* from the exterior, the focus being adjusted so as to bring out the reticulated layer with its great longitudinal bands *e, e,* connected by the transverse slips *e′, e′. A* the anterior, *B* the posterior margin of the segment, and *c* the folded edge. The fibres of the inner longitudinal muscular coat appear behind the transverse slips of the reticulated layer. × 90 diam.

[1] This and subsequent drawings are from preparations mounted in chloride of calcium.

Fig. 5.—Longitudinal and vertical section of the proboscidian sheath, *o*, of *Amphiporus spectabilis* (*Drepanophorus rubrostriatus*, Hubrecht) at the anterior third of the body. The apertures, *a e*, connecting the interior of the sheath with the vascular system lie near the dorsal part of the sheath. The muscular fasciculi are somewhat coarse. 90 diam.

PLATE XV.

Fig. 1.—Transverse section of the anterior chamber of the proboscis of *Amphiporus spectabilis*, De Quatref. (*Drepanophorus rubrostriatus*, Hubrecht) everted, and thus in the same state as Dr. Hubrecht's, with whose drawing[1] it may be compared. *b*, glandular (papillose) inner lining; *b'*, basement-layer on which the former rests; *c*, circular muscular coat; *d*, internal longitudinal layer; *e*, reticulated layer, the great longitudinal bands of which are lozenge-shaped in transverse section, and, moreover, fibres pass from the external tip of the lozenge to the outer layer; *e'*, intermediate transverse slips; *f*, external longitudinal muscular coat; *g*, external elastic layer with denser (muscular) fibres externally, a few being ruptured in the preparation. × 210 diam.

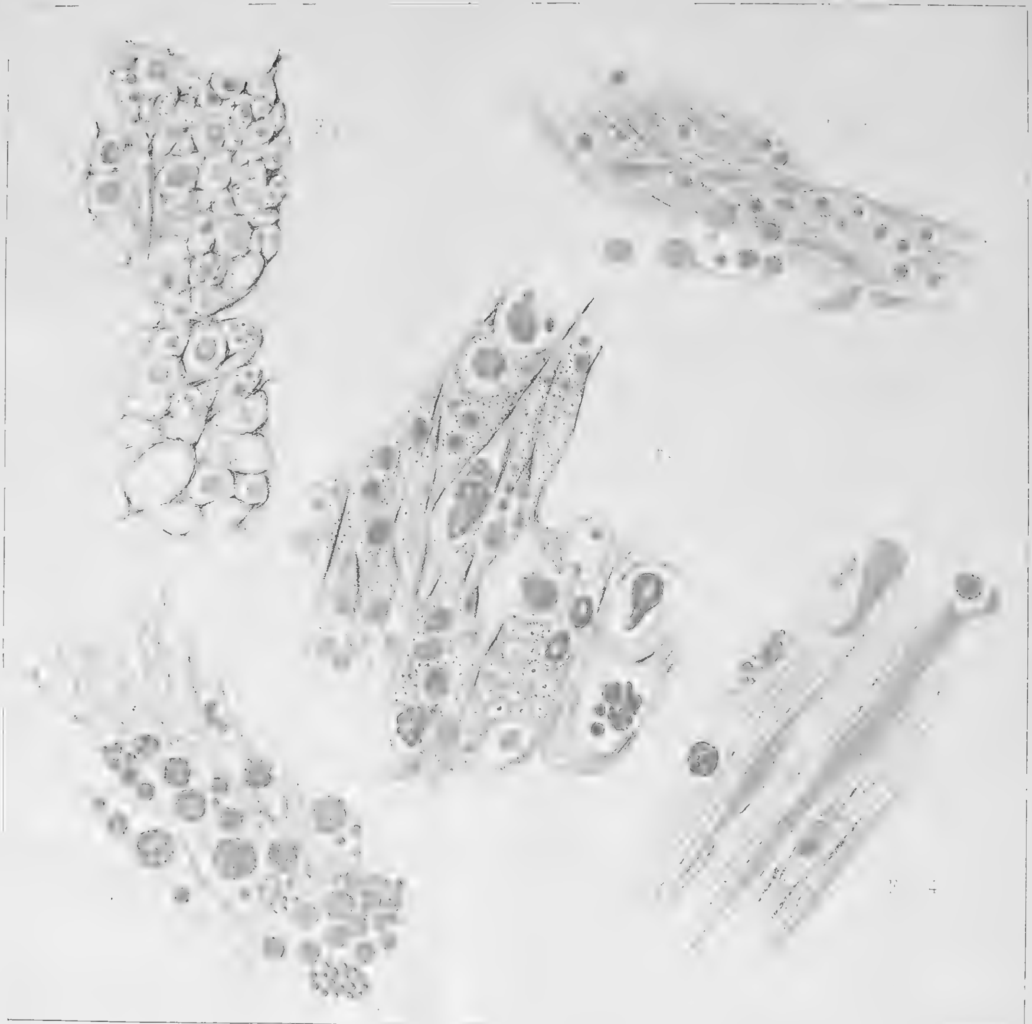
Fig. 2.—Area of the lateral nerve in *Amphiporus hastatus*—to exhibit the generative tubes and vessels. *e*, *e*, outline of the great longitudinal muscular layer of the body-wall. *g*, *g*, dorsal and ventral cellular tubes, which meet at *g'* to pass between the fasciculi of the muscle above the nerve-trunk—the usual mode of exit in such forms: the lower tube has been sliced obliquely and somewhat flattened; *j'*, refracting granules of the wall of the alimentary canal; *m*, vertical muscular band passing from the dorsal to the ventral region, and bounding the former; *n*, lateral nerve surrounded by its investment, the somewhat cellular appearance occurs only at the upper part of the section; *n b*, finely granular trunk apparently representing a nerve-branch to the longitudinal muscle (*e*); *v*, ventral vessel; *v'*, supraneural vessel. × 210 diam.

[1] Aanteekeningen, &c., Plate II, fig. 2.

Fig. 1

Fig. 2

XV.



D J Hamilton, del.

Mc Farlane & Erskine Lith.rs Edin.r

JOURNAL OF MICROSCOPICAL SCIENCE.

EXPLANATION OF PLATE XVI,

Illustrating Dr. D. J. Hamilton's paper on Myelitis.

Fig. 1.—Transverse section in inflamed region showing transverse section of immensely enlarged axis cylinders.

Fig. 2.—Transverse section showing the contracted axis cylinders undergoing division. The divisions become rounded, and form colloid bodies; in some an apparent nucleus can be seen.

Fig. 3.—Portion of the anterior commissure, showing several nerve-tubes with dilatations on their axis cylinders. Some of these are completely separated and are becoming granular.

Fig. 4.—Longitudinal section of one of the white columns, showing enlarged axis cylinders; at the end of one a large granular corpuscle can be seen separating.

Fig. 5.—Longitudinal section of one of the white columns, showing the formation of pus-corpuscles from the large granular corpuscles seen in Fig. 4.

EXPLANATION OF PLATES XIX & XX,

Illustrating Mr. Worthington G. Smith's paper on the Resting-Spores of *Peronospora infestans*, Mont.

PLATE XIX.

Photographs showing the oogonia and antheridia of *Peronospora infestans* in conjugation, × 300 diam. It will be found of advantage to examine them with a magnifying lens.

PLATE XX.

KEY TO THE PHOTOGRAPHS IN PLATE XIX.

Upper figure.

A, A, A.—Oogonia, showing the dark coat.

B.—Ditto; a hypha can here be seen underneath.

C.—Ditto, sessile oogonium, having the spurious appearance of being within the mycelium whilst it is really upon it.

D, D, D.—Antheridia.

E.—Antheridium perfectly mature.

F.—Antheridium immature or abortive.

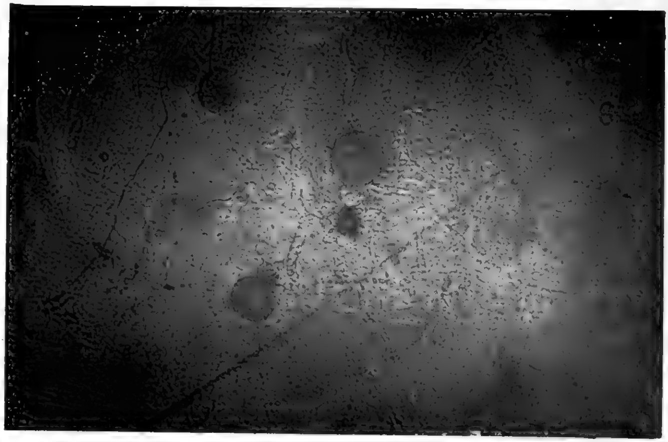
Lower figure.

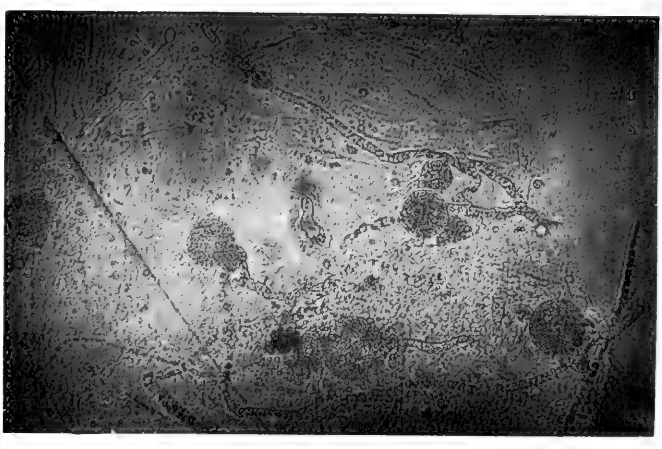
G, G, G.—Oogonia.

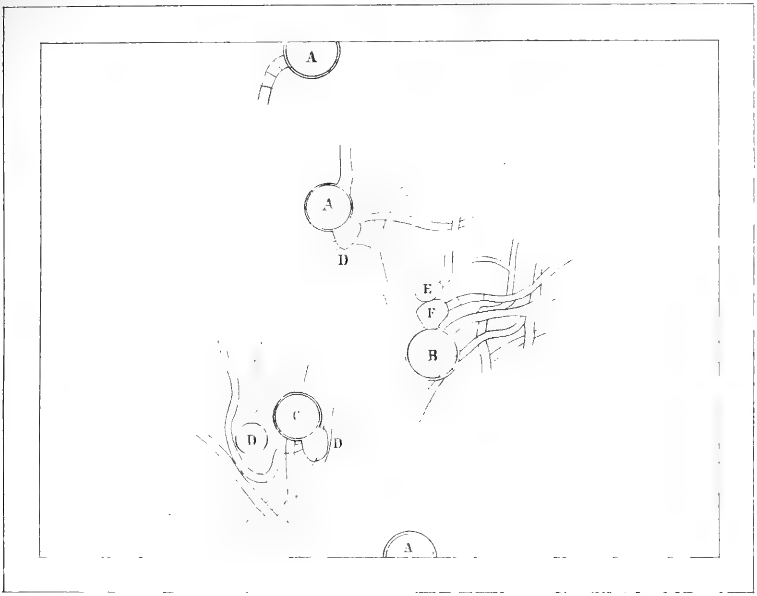
H.—Sessile oogonium as in figure above (C).

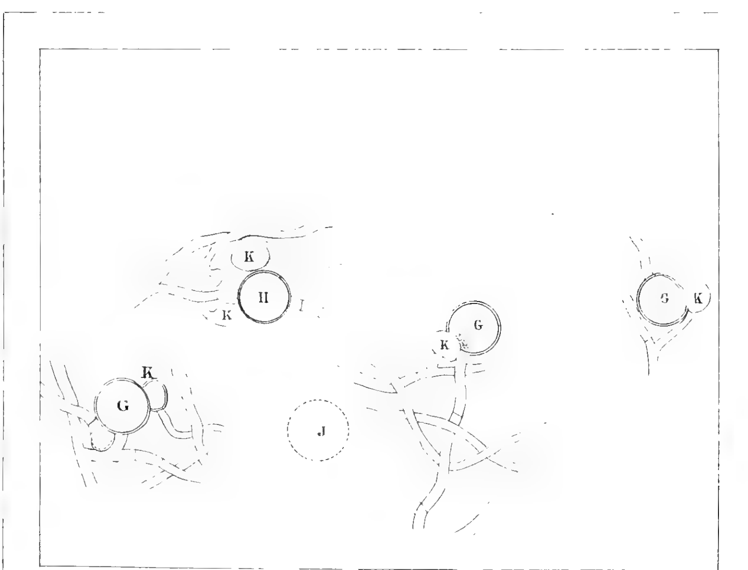
J.—Oogonium burst by the sun's rays whilst being photographed.

K, K, K, K, K.—Antheridia.

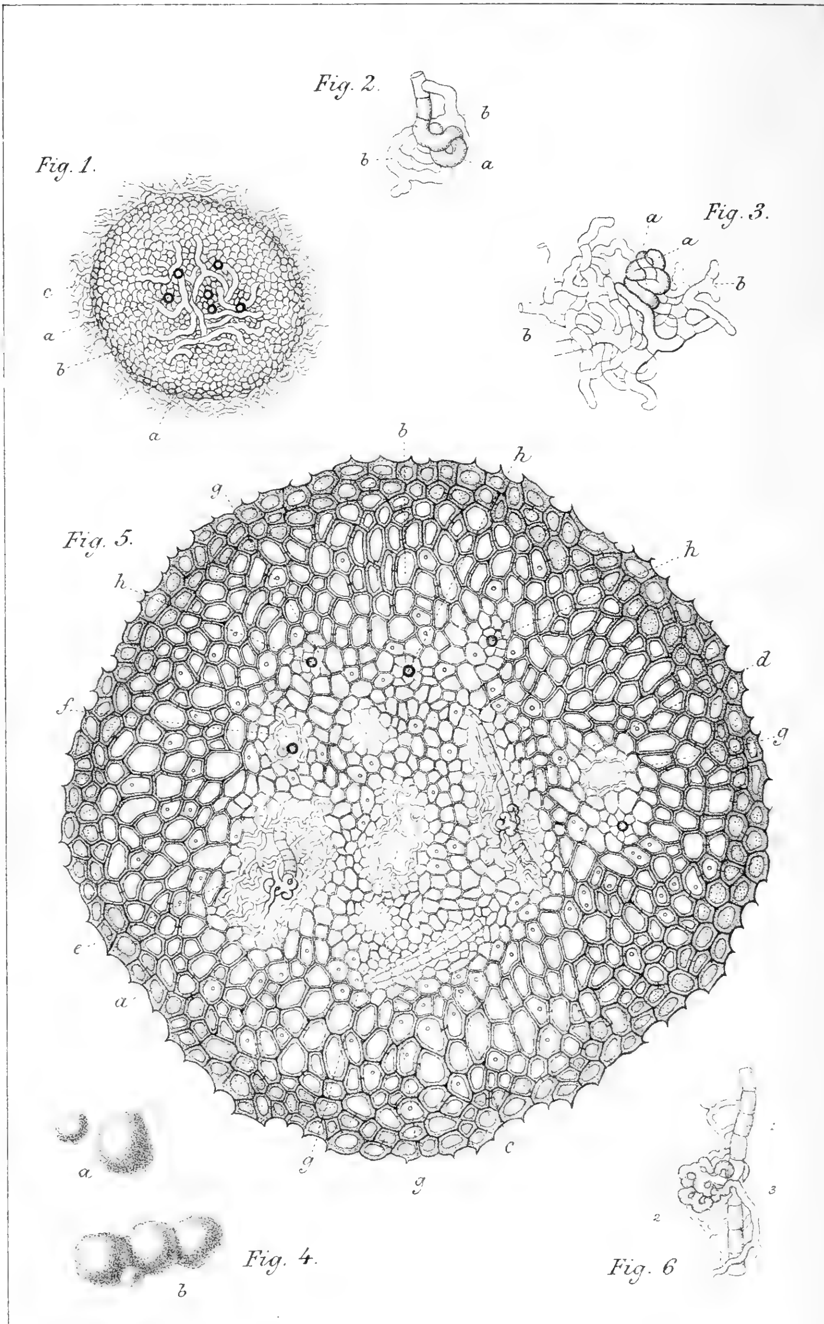








Vincent Brooks Day & Son lith.



O Brefeld, del[t]

Mc Farlane & Erskine Lith[rs] Edin[r]

Fig. 7.

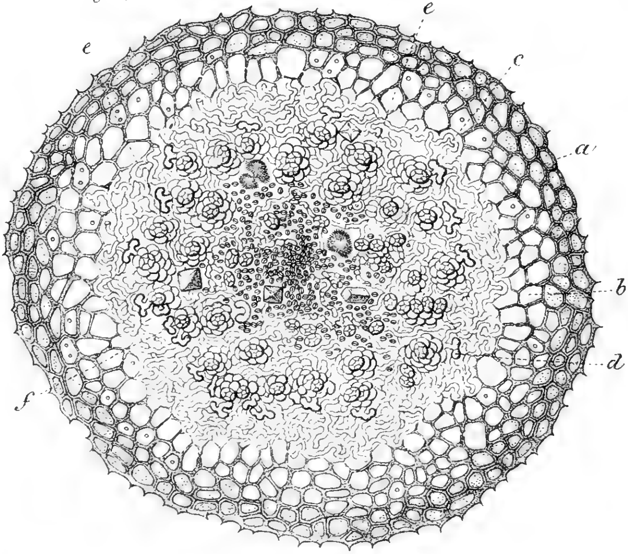


Fig. 8.

Fig. 10.

Fig. 9.

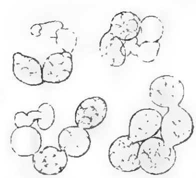


Fig. 11.

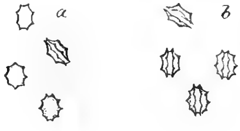


Fig. 12.

O. Brefeld, delt.

Mc Farlane & Erskine, Lithrs Edinr

EXPLANATION OF PLATES XVII & XVIII,

Illustrating Prof. M'Nab's paper on the Life-History of Penicillium.

FIGS.

1.—Young sclerotium in transverse section. *a.* Carpogonium-hyphæ surrounded by sterile tissue; *b*, the cells of the sterile tissue, smallest near the carpogonium-hyphæ; *c*, mycelial hyphæ. × 300 diameters.

2.—Sexual organs after fertilisation. *a.* Fertilized carpogonium; *b*, sterile hyphæ, which appear near carpogonium after fertilization. × 630 diameters.

3.—The same in a more advanced stage. The enlarged carpogonium in *a* nearly surrounded by the sterile hyphæ *b*. × 630 diameters.

4.—Sclerotia of Penicillium. *a.* Simple sclerotia showing extremes in size; *b*, coherent sclerotia. × 15 diameters.

5.—Section of sclerotium of Penicillium after cultivation for eight weeks. *a.* Marginal zone; *b*, sterile (nutrient) tissue; *c*, carpogonium-hypha with transverse septa; *d*, portion of another carpogonium-hypha with the cells producing branches of two kinds, the thicker afterwards forming the asci, the thinner the nutrient mycelium; *e*, carpogonium-hyphæ showing both thick and thin branches arising from the same cell; *f*, carpogonium-hypha cut across; *g*, empty space out of which the carpogonium-hyphæ have dropped; *h*, carpogonium-hypha surrounded by a rosette of cells. × 300 diameters.

6.—Developing carpogonium-hyphæ. 1. Septate carpogonium-hypha; 2, ascus-producing branch with its curved apex; 3, much-branched mycelial (nutrient) hypha. × 630 diameters.

7.—Section of sclerotium of Penicillium after cultivation for from 5—6 months. *a.* Yellow marginal zone; *b*, sterile tissue; *c*, mycelial hyphæ; *d*, hyphæ bearing asci; *e e*, crystals of calcium oxalate; *f*, ripe spore. × 300 diameters.

8.—End of hypha bearing an ascus with nearly ripe ascospore. × 630 diameters.

9.—Ascus-bearing hyphæ, some of the asci ripe. × 630 diameters.

10.—Axial hypha with all the asci detached from their stalk-like bases. × 630 diameters.

11.—Ascospores of Penicillium. *a.* upper view; *b*, side view. × 800 diameters.

12.—Germination of ascospores in fruit juice; *a*, by splitting of exosporium into halves; *b*, by one-sided opening. × 800 diameters.

EXPLANATION OF PLATE XXI,

Illustrating Dr. E. Klein's Observations on the Structure of the Spleen.

FIG. 1.—Dog's spleen injected with one tenth osmic acid, and then hardened in Müller's fluid, showing the structure of matrix of pulp.

a. Cavities containing lumps of blood-pigment.
b. „ „ blood-corpuscles.
c. Apparent fibres—in reality only ridges of the general matrix.

FIG. 2.—Human spleen hardened in chromic acid.

a. Venous sinus. To the left of it the wall of a sinus, lying in a layer above, is seen *en face.*

FIG. 3.—From the same spleen as fig. 2, showing the structure of the matrix of pulp.

a. Venous cavities of the pulp.
b. One that contains a budding cell.

FIG. 4.—From the same spleen, showing the structure of the wall of a venous sinus, A being the one, B being the other wall seen in profile.

a. The endothelium bordering the lumen.
b. Pulp substance.

FIG. 5.—From the same spleen; marginal part of a Malpighian corpuscle.

a. Matrix.
b. Budding lymphoid cells.

All these figures are drawn under Hartnack Oc. III; Obj. Immersion 10.

FIG. 6.—From a section through an injected spleen of monkey.

a. Venous sinuses in transverse section.
b. Matrix of pulp.

Oc. II; Obj. Immersion 10.

FIG. 7.—1, 2, 3, 4, very large cells of the matrix, containing numerous budding nuclei—giant cells.

a. Matrix of the cells.
b. Nuclei.
c. Spaces, *d* containing blood-corpuscles.

Oc. III; Obj. 10 Immersion.

E. Klein, del[t].

M[c] Farlane & Erskine, Lith[rs] Edin[r]

Fig. 1.

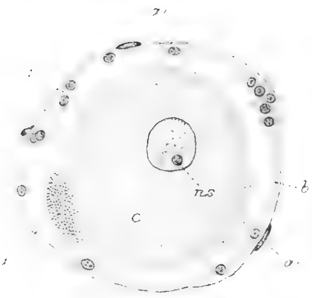


Fig. 2.

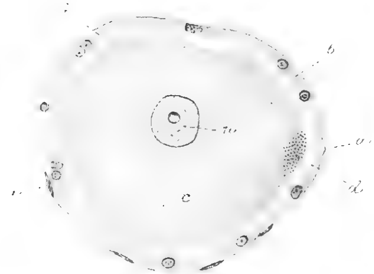


Fig. 3.

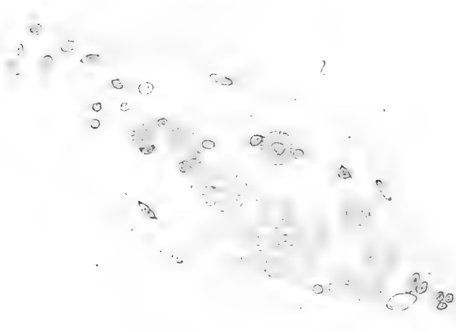
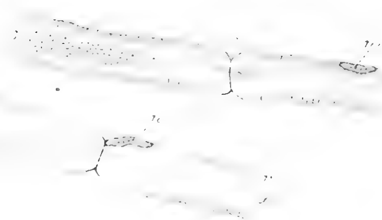


Fig. 4.



EXPLANATION OF PLATE XXII,

Illustrating Mr. McCarthy's Remarks on Spinal Ganglia and Nerve-Fibres.

Figs. I and II represent two of the larger ganglion-cells

a. Fibrous capsule, with nuclei of connective-tissue corpuscles. *b.* Nucleated hyaline layer, showing the various arrangements of the nuclei, some of which appear to be undergoing, or to have recently undergone subdivision. *c.* Molecular matter, granular externally, fibrillated internally. *d.* Pigment-granules. *n.* Nucleus. *ns.* Nucleolus.

Fig. III.—Transverse section of a small bundle of nerve-fibres which lay outside the main nerve-trunk at a little distance beyond the ganglion

c. Nucleated fibrous perineurium. *l.* Lymphatic sheath, with endothelial lining. *e.* Endoneurium of Axel Key and Retzius. *f.* Nerve-fibres with sheath of Schwann in parts nucleated, and with rod-like striation of medullary sheath, the arrangement varying as described in text. (Only some fibres have been represented for the sake of clearness.)

Fig. IV.—Two nerve-fibres cut longitudinally.

n. Nucleated sheath of Schwann. *c.* Ranvier's constrictions. *r.* Rod-like striation of medullary sheath seen in profile. *s.* Seen from the surface. *a.* Axis cylinder.

Note.—In Figs. I, II the separation between the limiting membrane and body of the ganglion-cell is exaggerated; such separation is neither constant nor complete, and when present appears to me to be artificial and the result of the reagents employed.