QUARTERLY JOURNAL

OF

MICROSCOPICAL SCIENCE.

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EDITED BY

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AND

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VOLUME I.

With Woodcuts, Lithographic and Photographic Plates.

LONDON:
SAMUEL HIGHLEY, 32, FLEET STREET.
1853.

LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

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VOLUME I.

PREFACE.

RECENT improvements in the Microscope having rendered that instrument increasingly available for scientific research, and having created a large class of observers who devote themselves to whatever department of science may be investigated by its aid, it has been thought that the time is come when a Journal devoted entirely to objects connected with the use of the Microscope would contribute to the advancement of science, and secure the co-operation of all interested in its various applications.

The object of this Journal will be the diffusion of information relating to all improvements in the construction of the Microscope, and to record the most recent and important researches made by its aid in different departments of science, whether in this country or on the continent. A department of the Journal will be given to reviews of works, or those parts of works which are devoted to subjects of inquiry in which the Microscope is employed. It is the wish of the Editors to conduct this department in a friendly spirit, regarding all who labour honestly in the field of science as co-workers for the common good. In order to gather up fragments of information, which singly might appear to be useless but together are of great importance to science, the Editors have opened a department for short notes, memoranda, and correspondence, to which they would especially invite the attention of their scientific friends, as they believe there are few possessors of a Microscope who have not met with some stray fact or facts which, published in this way, may not lead to important results. They hope also to relieve the graver and more strictly scientific matter of the Journal by lighter contributions, such as will be found useful to the beginner, not uninteresting to the advanced observer, and of interest perhaps to the general reader.

In a Journal of this nature illustrations are indispensable, as it is difficult to convey an accurate idea of objects observed by description alone; but as it is impossible to give a fixed amount, the Publishers have determined to afford, *on an average,* with each number, four lithographic plates, and such woodcuts as may be necessary; and they congratulate themselves in having secured for this department the services of Mr. Tuffen West, as their artist, to whose plates in the present number they may confidently appeal, as examples of the manner in which they wish to illustrate the Journal in future.

In announcing the objects they have in view, the Editors would especially call attention to the connexion of this Journal with the Microscopical Society of London, as it is mainly through the readiness expressed by the Council of that Society to co-operate with the Proprietors and Editors, in order to diffuse more widely, and to publish more regularly, their Transactions, that the Journal owes its existence in its present form.

The papers published under the head of 'Transactions of the Microscopical Society of London' are selected by the Council of that Society; for its other contents and general conduct the Editors are alone responsible.

It is, perhaps, hardly necessary to apologise for the title of the Journal, as the term "Microscopical," however objectionable in its origin, has acquired a conventional meaning by its application to Societies having the cultivation of the use of the Microscope in view, and so fully expresses the objects of the Journal, that it immediately occurred as the best understood word to employ. It will undoubtedly be a Journal of Microscopy and Histology; but the first is a term but recently introduced into our language, and the last would give but a contracted view of the objects to which the Journal will be devoted.

As the success of their undertaking must mainly depend on the cordial assistance and co-operation of those who are engaged in prosecuting microscopical investigations, the Editors would urge upon them the importance of their assistance in making known the nature and objects of 'The Quarterly Journal of Microscopical Science,' and in becoming contributors to its pages.

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ORIGINAL COMMUNICATIONS.

On the Anatomy of MELICERTA RINGENS. By W. C. WILLIAMSON, Esq., Professor of Natural History, Owen's College, Manchester.

THE appearance of large numbers of the *Melicerta ringens* amongst the plants growing in my Vallisneria trough has afforded me an opportunity of subjecting this fine Rotifer to a careful examination; the result has been the elucidation of some portions of its anatomy which had not been fully worked out by Leeuwenhoek, Schäffer, Dutrochet, or Ehrenberg.

The ordinary appearance of this object is too well known to need a description. Its general aspect, when removed from its tessellated case, is represented by fig. 14, Pl. I. The four flabelliform rotatory organs (14 *a*), when forced out of the body (into which they can be withdrawn) and fully expanded, are seen to be clothed with ciliæ over their entire surface; those fringing the margin being the longest and most conspicuous. On one side of the neck are the two small incurved processes (14 *b*), which Schäffer calls the lips. When the animal withdraws the rotatory organs into the fore part of its body, which it does when alarmed, these hooks constitute two of the most prominent points of its body. On the opposite side to that occupied by these appendages there is a fifth and smaller rotatory organ (1 *c*), with a thickened margin, from which radiating bands proceed inwards to its point of attachment. This organ is also ciliated. On each side of it, and opposite to the two hooks, there are two long tentacles (14 *d*), the homologues of organs which are common amongst the Rotifera. To these Ehrenberg has assigned respiratory functions, whilst Dujardin regards them as more closely resembling the antennæ and palpi of the Entomostraca. When one of these tentacles in the Melicerta is fully protruded it is seen to be terminated by a brush of fine divergent setæ (15 *a*), implanted on the convex side of a small deltoid body (15 *b*); from the flat side of this latter appendage there proceeds along the interior of the tube, towards the body of the animal, a delicate muscular band (15 *c*), which, by its contractions, draws the deltoid body backwards, thus inverting the extremity of the tube and forming a double sheath protecting the setæ (16). This inversion of the tube was, I believe, first noticed by Dutrochet. The whole apparatus is, as suggested by Schäffer, very similar to that seen in the tentacles of the snail, and appears to constitute a tactile rather than a respiratory organ. This is rendered the more probable by the fact, that when the animal first emerges from its tessellated case, the extremities of these two tentacles are the first parts that make their appearance, the two curved hooks being the next. The setæ are usually half-drawn into the inverted tentacle, but they project sufficiently forward to constitute delicate organs of touch, supposing the deltoid body into which they are inserted to be endowed with sensibility. The animal cautiously protrudes these tentacles before it ventures to unfold its rotatory organs, but it does not direct them in an exploratory manner from side to side, as an insect does its antennæ.

The alimentary canal commences with a small oral orifice, situated near the centre of the sinuated disk formed by the rotatory organs. It opens into an œsophagus, which conducts the food down to the gastric teeth (14 *e*). These are implanted in a large conglobate cellular mass, which completely invests them. Their appearance is accurately represented by fig. 17: they consist of two essential portions—a pair of strong crushing plates, which bruise the food, and various appendages affording leverage and facilitating the action of the muscles upon them. The crushers are two broad elongated plates (17 *a*), each being about 1-800th of an inch long, and separated from each other at the mesial line, near which they become much thickened. From each of these plates there proceed laterally numerous parallel bars (17 *b*), all of which are somewhat thickened at their inner extremities where they are attached to the plates, whilst at their opposite ends they are united with the others of the same side by a curved connecting bar (17 *c*), from the outer sides of which are given off various loops and processes. The three uppermost of these bars are the largest, the rest gradually diminishing in size and strength as we descend, the inferior ones being almost invisible. From the upper extremities of the two crushers there project upwards and backwards two slender prolongations (17 *d*), united by a kind of double hinge-joint near their apex, where they not only play upon each other, but also on a third small central fixed point (17 *e*) lodged in a little conglobate cellular mass. Ehrenberg only describes three transverse bars on each side, which he regards as teeth. It is obvious that he has only noticed the three upper and larger pairs. It is equally evident that these transverse teeth, as he terms them, do *not* move upon the strong longitudinal plates, as he imagines, but are firmly united with them. Muscles are either attached to the divergent peripheral processes, or to the cellular mass in which these processes are imbedded, causing the entire apparatus to separate into two parts along the mesial line, by means of the hinge joint at 17 *c*, the so-called teeth merely transmitting the motor force to the two longitudinal plates. These latter appendages are thus made to play upon each other with great power, and act as efficient crushers, bruising the food before it passes into the stomach, as is the case with the gastric teeth of the crustacea. From the above remarks it will be seen that, though in its construction the dental apparatus is more complex than is represented by Ehrenberg, in its mode of working it is less so.

The conglobate organ in which this apparatus is imbedded is transparent, and composed of numerous large cells, each of which contains a beautiful nucleus, with its nucleolus. The cells are only seen when the organ is ruptured between two plates of glass, when they readily separate from one another; but the nuclei, with their contained nucleoli, are distinctly visible in the living animal. Delicate muscular threads most probably penetrate this organ to reach the dental apparatus, though I have not yet detected them.

After passing the dental organs, the food enters an elongated stomach (14 *f*), with very thick pulpy parietes. In young examples these walls are colourless and transparent, but in more matured specimens they exhibit a bright olive-yellow hue. The whole cavity, as well as the œsophagus leading into it, is lined with ciliæ, which are constantly playing. On rupturing this organ we perceive that it is composed of a thin pellucid external membrane, which exhibits no structure, but within which is a thick layer of large turgid epithelial cells. These are easily detached from the membrane, when each one is seen to be spherical, containing numerous yellow granules, and very often a nucleus with its nucleolus. The ciliæ are attached to one side of these cells, the great length of these appendages constituting the most marked feature of the structure. It often equals the entire diameter of the cell. Some of the cells exhibit no ciliæ; others are only furnished with them on one side; whilst a few appear to be fringed with them throughout their entire circumference. I presume that in the latter case the cells have projected considerably into the cavity of the stomach. The yellow granules are absent from those of young animals, showing clearly that it is these contained granules that give the colour to the parietes of the stomach in matured individuals. The connexion between the cells is very slight, since but little pressure suffices to detach them from their position without marring their integrity. By their aggregation they constitute a true epithelial structure, lining a thin and apparently structureless membrane; but from the constant automatic movements of the viscus, it is possible that this latter membrane may contain minute muscular fibrillæ. The great thickness of the epithelial layer, as compared with the entire diameter of the organ, is curious. Whilst the latter averages about 1-250th of an inch, the former is often not less than 1-1500th, or 1-6th of its entire diameter. The cells when detached vary in size, from a diameter of 1-1000th to 1-1600th of an inch: one of these, which was fringed with ciliæ, 1-1600th of an inch long, is represented in fig. 18, its nucleus being about 1-7000th of an inch. After being detached, some of the ciliated cells floated slowly away, like so many animalcules.

This stomach appears to be chiefly a receptacle for the food. From time to time, especially when the viscus is distended, a portion of its contents pass down into a lower stomach (14 *g*), which is separated from the upper one by a marked though varying constriction. This second stomach is also lined with ciliæ, which are even longer than those of the upper viscus; but the parietes are very much thinner and more transparent, the cells being less easily traced. The diameter of the organ is nearly the same in each direction, so that it is almost spherical. The mass of food with which it is usually distended is constantly revolving, the motion being due to ciliary action. This process goes on for some minutes, after which the creature contracts its body, and forces the entire exuviæ out of the viscus into a long narrow cloaca, which terminates externally by an anal outlet at 14 *h*. As it does this, it everts a considerable portion of the cloaca; thus almost bringing the cloacal outlet of the stomach to the exterior, and causing at the same time a large transparent protuberance (14 *i*) to be developed on the corresponding side of its body. At other times the creature can draw in these appendages, so that scarcely any trace of a cloacal canal is visible.

Nearly on a level with these stomachs is the ovary (14 *k*), an oblong organ, extending from near the oral orifice, superiorly, to the centre of the lower stomach in the opposite direction. It is a pellucid membranous bag, distended with granular protoplasm, in which are dispersed numerous nucleolated nuclei.

The oviduct consists of a prolongation of the membrane of the ovary. It winds round the inferior border of the lower stomach (14 *l* and 19 *b*), and enters the cloaca near the point where the lower stomach opens into that excretory canal.

I have sought in vain for any organ to which the functions of a spermatic gland can be indisputably assigned. Immediately beneath the lower stomach and the contiguous oviduct, there is an elongated pyramidal organ (14 *m* and 19 *d*), apparently hollow, the thick extremity of which is directed towards the ovary, and its opposite attenuated portion passes upwards towards the cloaca, between the oviduct and the general integument. Into the thick inferior extremity of this organ there are inserted, exactly opposite to each other, two long cylindrical appendages, which diverge, and, passing on each side of the alimentary canal, proceed towards the upper part of the body, where their extremities are not easily traced. In but one instance I observed them to terminate in a series of irregular convolutions near the base of the two tentacles. Though not yet capable of demonstration, it appears probable that this curious appendage may be a filamentous spermatic tube, resembling those found in many of the articulata. That they are tubes, and not muscular bands, appears unquestionable; and as they have obviously a direct connexion with the cloaca, they might easily discharge a fertilising secretion into that common excretory canal, from which it would find its way to the ovary through the oviduct.

The muscular system is developed in an interesting manner. Distinct muscular bands occur at intervals in the common tegument, concentrically encircling the entire organism. Their action is easily observed. Still larger and more distinct fasciculi run lengthwise; some of these proceed from the upper part of the visceral cavity to the base of the tail or peduncle, where (19) they are inserted into a thickened portion of the integument. Others, taking their rise from various parts of the body, proceed along the caudal prolongation (14 *n*, 19 *g*, and 20 *a*), and are inserted into a little concavo-convex body (14 *o*, 20 *b*) at its extremity. This latter group of muscles is easily examined, owing to the exceeding transparency of the integument. On rupturing the muscular fasciculi transversely, we perceive that each one is invested by a delicate sarcolemma (21 *a*). This is well seen at the upper part of the tail, where, on the contraction of the muscle, the non-elastic sarcolemma becomes corrugated (21 *b*), and only recovers its smooth aspect when the muscle becomes relaxed. These rugæ of the sarcolemma must not be confounded with the transverse striæ of the muscular fibre. When one of these muscular fasciculi is drawn out at full stretch, its surface is seen to be marked at very regular intervals by dark transverse bars (22). Each fasciculus has a diameter of about 1-3500th of an inch, and the transverse striæ recur at distances of about 1-9000th. These intervals are, of course, rather larger than those seen in the fasciculi of human voluntary muscle. The bars extend entirely across the fasciculus. There can be no doubt that this structure is the homologue of what occurs in the voluntary muscles of the higher animals.

The general integument consists of a thin and very transparent membrane. In this are embedded numerous concentric muscular bands already referred to. In the skin surrounding the visceral cavity there are also longitudinal fibres; whilst, in the rotatory organs, corresponding threads, which I presume to be muscular, interlace in various directions.

The small organs which are so common amongst the Rotifera, and which Ehrenberg regards as nervous ganglia, are abundant in the *Melicerta;* but they afford no countenance to the hypothesis of the great Prussian Professor. They appear to be nothing more than small cells or vesicles formed of granular viscid protoplasm, very similar to that into which, as we shall immediately find, the yolk of the egg becomes divided. Sometimes they float freely in the fluid which distends the integument and bathes the viscera (14 *p*). At others, thin ductile threads pass from one vesicle to another, as seen in fig. 19 *h*, where these objects are delineated as they appeared in one individual, in the clear space immediately below the viscera. In this case they are more abundant than is usual. There is no uniformity in their arrangement in different individuals. They differ as widely as is possible in their size, number, and distribution. So far from being nervous vesicles, they appear rather to be cells, modified into a rudimentary form of areolar tissue. That they are hollow vesicles or cells, very viscous, readily cohering, and, owing to this coherence readily drawn out by the movements of the various organs to which they are attached, are facts capable of easy demonstration.

[To be continued.]

Observations on the CONTRACTILE TISSUE *of the* IRIS. By JOSEPH LISTER, Esq., B.A.

Our knowledge of the cause of the movements of the iris was till within the last few years in a very unsatisfactory condition. That this organ possessed contractile fibres was a matter of inference, not of direct observation. In the third part of the last edition of Quain's Anatomy, published in 1848, we find it stated (p. 915) that the radiating and circular fibres of the iris are generally admitted to be muscular in their nature, but the grounds for that admission are not mentioned. Mr. Bowman's Lectures on the Eye, delivered in the summer of 1847, and published in 1849, show us that the then state of histology in this country did not enable that accomplished microscopical anatomist to identify the fibres of the iris with other plain (unstriped) muscular tissue. At page 49 he says, "The fibres which make up the proper substance of the iris are of a peculiar kind, very nearly allied to the ordinary unstriped muscle, but not by any means identical with it." He afterwards goes on to argue that, as we know that the organ changes its form, and as its vessels are so distributed that it cannot be erectile, we have no other resource than to consider its fibres contractile, which conclusion he supports by reference to the striped fibres in the iris of birds and reptiles.

In 1848 Professor Kölliker announced to the world his grand discovery of the cellular constitution of all plain muscular tissue, in a full and elaborate paper in the 'Zeitschrift für Wissenschaftliche Zoologie.'* At p. 54 of the first part of the first volume of this journal, after speaking of the arrangement of the fibres of the ciliary muscle, the sphincter pupillæ, and dilator pupillæ, he makes the following statement:—"The elements of all these muscles are undoubtedly smooth muscular fibres. In man I have but seldom succeeded in isolating the individual fibre-cells, but I have had more frequent success in the case of the sheep, where I found them in the ciliary muscle, on an average, 1-600th of an inch in length, and 1-4000th to 1-3000th of an inch in breadth. In man, in all these muscles one sees, as a rule, only parallel fibres projecting

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* Professor Kölliker may almost be said to have been anticipated in this discovery by Mr. Wharton Jones. Through the kindness of that gentleman, I have now before me two original drawings, made by him about the year 1843, of plain muscular tissue from the small intestine. In one of these the muscular fibre-cells are characteristically shown, except that their nuclei are not apparent; one of them is wholly isolated. In the other drawing, the alternate disposition of the fibre-cells is seen after the addition of acetic acid. He also observed, as he informs me, that the unstriped muscle of the œsophagus and stomach, and also of the uterus and other organs, consisted of similar elements—a fact which he yearly communicated to his class in his public lectures at Charing Cross Hospital. He was led, from appearances in the embryo, to infer that striped muscular fibre is originally composed of similar elements, which, in the process of development, are enclosed in a sarcolemma common to many of them, and become split into fibrillæ. He thus accounted for the nuclei of striped muscular fibre, which, according to this view, are the persistent nuclei of the primitive muscular fibre-cells.—J. L.

to a greater or less extent at the edges of small fragments of the tissue, these fibres exhibiting in abundance the well-known elongated nuclei, either with or without the aid of acetic acid. In man, the muscle of the choroid (ciliary muscle) has broader and more granular fibres and shorter nuclei than the iris. In the former the nuclei measure from 1-2400th of an inch to 1-1333rd of an inch; in the latter as much as 1-1090th of an inch."

Here, then, we have, so far as I know, the first and only recorded observation of tissue in the iris identical with ordinary unstriped muscle.

It is to be remarked that, where he alludes in the passage above quoted to having in rare cases separated the individual fibre-cells of the muscular tissue, Professor Kölliker speaks of the three muscles (ciliaris, sphincter, and dilator) collectively; in other words, that he does not tell us in plain terms that he has isolated the fibre-cells of the iris at all. Now, the ciliary muscle is confessedly easier to deal with than the iris. Mr. Bowman, who speaks so doubtfully of the fibres of the iris, says of the ciliary muscle, "the fibres are seen to be loaded with roundish or oval nuclei, often precisely similar to those of the best marked examples of unstriped muscle" (op. cit., p. 53). Another very eminent microscopical anatomist has informed me, as the result of his experience, that it was easy to identify the tissue of the ciliary muscle with that of other organic muscle, but that this had not been the case with the iris. That Professor Kölliker's isolation of the fibre-cells of the muscles of the eye was in reality confined to the ciliary muscle is rendered probable by the fact that, while the whole article quoted from shows a manifest desire on the part of its author to give all available detail, yet regarding the iris he mentions no facts requiring isolation of the fibre-cells for their determination; while, on the other hand, he tells us that the fibre-cells of the iris are narrower than those of the ciliary muscle, and gives the length of the nuclei in the human iris—things which are very readily observed without isolation of the fibre-cells. His figures refer to the human ciliary muscle alone; and the only measurements given by him of muscular fibre-cells from the eye refer to the same muscle in the sheep.

It would seem, then, that with regard to the iris, Kölliker's proof falls short of the test of isolation of the fibre-cells.

An operation for artificial pupil, by excision, performed by Mr. Wharton Jones, at University College Hospital, on the 11th of August of the present year (1852), placed in my possession a perfectly fresh portion of a human iris, and, without knowing that Kölliker's observations had extended to the muscles of the eye, I proceeded to avail myself of this somewhat rare opportunity of investigating the muscular tissue of the human iris. On placing under the microscope, four hours after the operation, portions of the tissue carefully teased out in water with needles, I found that some of the muscular fibre-cells had become isolated, and presented very characteristic appearances. I accordingly made camera lucida sketches of the finest specimens, which are reproduced on a smaller scale in the accompanying figures (see Pl. I., fig. 7-11). I drew the last cell (fig. 8) 9½ hours after the operation. And here I may mention that I have not found the muscular fibre-cells by any means a very perishable tissue. After an iris has been soaking two or three days in water, the muscular tissue of the sphincter is still quite recognisable, not only by the nuclei, but also by the individual fibre-cells.

Of the figures above referred to, (7) and (8) are examples of the most elongated cells that I saw. By reference to the scale it will be found that the cell (7) is about 1-125th of an inch in length, and about 1-3750th of an inch in greatest breadth; while (8) is a little shorter, but of about the same average breadth. Kölliker divides muscular fibre-cells into three artificial divisions, according to their shape, of which the third contains the most elongated and most characteristic cells. Of this third division, the cells (7) and (8) are good examples, and, in fact, correspond in their measurements to average fibre-cells of the muscular coats of the intestines. The cells (9) and (10), though less characteristic in respect of their length—(9) being about 1-333rd of an inch in length, and 1-3000th of an inch in breadth, and (10) 1-300th of an inch by 1-3000th of an inch, yet present the same peculiar delicate appearance and soft outline, and the same elongated nucleus, of not very high refractive power relatively to the contents of the cell, but clearly defined. All these cells have the same flat or ribbon-like form which is exhibited by the cell (8) at (*a*), where one edge has become turned up by a folding of the cell; at (*b*) there seemed a tendency to transverse arrangement of the granules of this cell, which tendency is more strikingly exhibited at *b* and *c* in the cell (11), which, though not isolated, is introduced on that account. This tendency to transverse arrangement of the granules was long since noticed by Mr. Wharton Jones, as that gentleman has since informed me, and is, indeed, indicated in the drawings which are alluded to in the note above. In the cells of this iris, however, it was not by any means constant. Some of them, as (7) at (*a*), and (9) at (*a*) and (*b*), exhibited something of a longitudinal arrangement of the granules, such as was noticed some years since in unstriped muscle by Mr. Bowman, who considered the rows of granules as an approach to the fibrillæ of striped muscle. These cells are more granular than I have found those of the iris of the horse to be; but I may here mention that, on comparing with these drawings the outline of a fine specimen of a muscular fibre-cell of the sphincter pupillæ of this animal, which I had sketched by the camera lucida, I find it to be almost an exact counterpart of the cell (7) as regards the shape and size of both the cell and its nucleus. The nuclei of these cells measure from 1-1400th to 1-1110th of an inch in length, and about 1-9500th of an inch in breadth. They are not, however, the most characteristic that are to be found in the iris. Fig. 12 is from a camera lucida sketch of a nucleus of the sphincter pupillæ of a horse; it measures 1-840th by 1-15,200th of an inch, and exhibits in a very marked manner the true rod-shaped figure which appears peculiar to muscular fibre-cells. On the other hand, I found some instances in the human iris of fibre-cells with considerably broader nuclei than those in the figures. The iris that yielded these cells was a blue one, apparently perfectly healthy; it was active and brilliant before the operation, which was performed on account of central opacity of the cornea, resulting from an attack of a severe form of ophthalmia fifteen months previously. I watched the case closely from the first, and there was no reason to suspect implication of the iris in the inflammation.

Having thus satisfactorily verified the fact of the existence in the iris of tissue identical with ordinary unstriped muscle, I was naturally led to inquire into its distribution in the organ: and, as this is a subject of great interest, and one about which much difference of opinion has prevailed, I may mention here the facts which I have hitherto observed, although there be not very much of actual novelty in them.

Kölliker, in the article above referred to (loc. cit. pp. 53 and 54), describes a sphincter and dilator pupillæ, the former "very readily seen in the white rabbit, or the blue iris of man, from which the uvea has been removed, about a quarter of a line broad in man, exactly forming the pupillary margin, and situated somewhat nearer the posterior surface of the iris." Of the dilator he says, while confessing the difficulty of the investigation, that he believes it to consist of many narrow bundles, which run inwards separately between the vessels, and are inserted into the border of the sphincter.

Bowman, on the other hand, states (op. cit. p. 48) that, while in some instances a delicate narrow band of circular fibres exists at the very verge of the pupil, yet, in the majority of instances, he feels *sure* that no such constrictor fibres of the pupil exist. He ascribes the contraction of the pupil to the inner part of the radiating fibres, which, he says, are joined and knotted in a plexiform manner round the pupil. It is scarcely needful to observe that such a statement from such an authority could not but go far to impugn Professor Kölliker's assertion respecting the existence of a sphincter pupillæ.

My experience, I must confess, accords with that of Kölliker, viz. that the sphincter is readily seen, while the dilator is that whose investigation alone presents very serious difficulty. In the first iris that I examined with a view to the distribution of the muscular tissue, I was struck, after removing the usual pigment, with the appearance of a band on the posterior surface of the iris, near the pupil and parallel to its margin, quite evident to the naked eye, elastic and highly extensible. This proved to be the thickest part of the sphincter pupillæ. I have examined six human irides with reference to the distribution of the muscular tissue, but in none have I had any difficulty in recognising the sphincter, which I have also found equally distinct in some of the lower animals, viz. in the rabbit, the guinea-pig, and the horse. In man I find it about 1-30th of an inch in width, thickest towards its outer part, where it lies nearer the posterior surface of the iris than the anterior, and thinning off towards the pupil, where it forms a sharp margin, covered apparently on its anterior aspect only by some vessels and nervous threads and a delicate epitheliated membrane, which is thrown into beautiful folds when the pupil is contracted. The fibres of the sphincter are not absolutely parallel, and this deviation is probably produced in part by the dilating fasciculi sweeping in at various parts in a curved manner, and becoming blended with the sphincter. The reason for this supposition will appear hereafter. By teasing out under the microscope a portion of the actual pupillary margin, I found the sphincter to consist at this part of apparently unmixed muscular fibre-cells, without any connecting cellular tissue. Fig. 13 is a camera lucida outline of the edge of a portion of the sphincter so prepared, which edge is seen to be formed of projecting fibre cells, and similar appearances may be seen with great readiness under a high power, after stroking the pupillary margin with the point of a needle. Indeed, the great facility with which the tissue may be thus broken up appears opposed to the idea of the fibre-cells being united end to end into fibres, as the descriptions formerly given of unstriped muscle would lead one to suppose. The ends appear to separate as readily as the edges and surfaces, and it would rather seem as if the fibre-cells of a fasciculus were placed with their long axis in one direction, cohering generally to one another, but without the formation of longer fibres than each cell itself constitutes. I may here mention incidentally that in the circular coat of the aorta of the sheep, where the muscular tissue is disposed in thin layers among the elastic tissue, I have observed a distinctly alternate arrangement of the fibre-cells without any formation of fibres. Mr. Wharton Jones's drawing of alternately disposed fibre-cells in the small intestine has been alluded to in the note above. A portion of the outer and thicker part of the human sphincter pupillæ proved also extremely rich in muscular fibre-cells. In the rabbit and guinea-pig the sphincter has much the same appearance as in man, whereas in the horse it forms a wide but very flat band.

The dilating fibres of the iris present a very difficult subject of investigation.

And here I must express my belief—a belief the result of repeated and very careful observations—that the fibres described by Mr. Bowman as probably the contractile fibres of the iris are in reality the outer cellular coats of the vessels. The outer coat is very abundant in the vessels of the iris, and indeed even in the blue eye towards the sphincter quite obscures the bore of many of the vessels, and prevents the recognition of their vascular character, which can only be determined by tracing them to their more external and more obviously vascular trunks. The distribution of these vessels, radiating between the sphincter and the circumference of the iris, and forming in the region of the sphincter a close and knotted plexus, corresponds accurately with Mr. Bowman's description of the distribution of the fibres of the iris. His account of the tissue of these fibres, which he considers as probably contractile, harmonises with the characters of the cellular tissue that clothes the vessels. This is peculiar; consisting of very soft-looking fibres, whose fasciculi often require the best aid of a first-rate glass to resolve them into their constituent elements; destitute apparently of yellow elastic fibres, as in the case of the cellular tissue of the uterus, but, like this, containing abundance of free nuclei, of roundish or elongated form. The fibres are completely gelatinised by acetic acid. Now such a tissue can hardly, in the present state of our knowledge, be regarded as contractile; at any rate, if we can find any ordinary muscular tissue to account for the dilating action. On teasing out portions of the outer part of the human iris, I have found long delicate fasciculi, whose faint outline, absence of fibrous character, and possession of well-marked elongated nuclei parallel to the direction of the fasciculus, left no doubt in my mind that they were plain muscular tissue.

So far my observations regarding the dilator agree with Kölliker's, but whether or not these fasciculi are connected with the cellular coat of the vessels I have hitherto been unable to determine.

Among the lower animals the albino rabbit and guinea-pig appeared but little suited for the elucidation of this point. I have been most successful with the eyes of a horse, where, from the thickness of the iris and the abundance of pigment (for the eyes were black ones), I anticipated but little result from my examination. Having removed the uveal pigment from behind, I found that I was also able to strip off from the anterior surface a tough membrane, a portion of which, put under the microscope, appeared to be made up of peculiar short felt-like fibres, which were gelatinised by acetic acid. At and near the pupillary margin this membrane comes off in a continuous layer, leaving a delicate reticular structure, which contains the muscular tissue. It also contains vessels, as I proved by injection, and a black network, which consists of fine fibres, yellow, and highly refracting, more or less encrusted with pigment. I am uncertain whether or not this be a network of divided nerve-tubes with adhering pigment; in some spots the pigmental crust was absent from a considerable length of the fibres. The sphincter pupillæ is beautifully seen as a broad flat band, of extremely well-marked, unmixed, muscular fibre-cells; but crossing this at right angles are found, here and there, other flat bands of fibre-cells, which are in so thin a layer that without isolation the width of the individual cells cannot be seen, and they are evidently of similar dimensions to those of the sphincter. On addition of acetic acid their nuclei are also seen to be exactly like those of the sphincter. These bands divide in their course towards the pupil into several fasciculi, some of which cross over the sphincter at right angles till very near to its pupillary margin, and then seem to blend with the sphincter by making a slight curve. Most of the fasciculi, however, arch away earlier from their first course and join the sphincter in more or less oblique lines. The bands from which these fasciculi diverge may be traced away from the pupil for some distance, continuing their course at right angles to the sphincter till they are obscured by other tissues. Hence I think the inference may fairly be drawn that these are the insertions of the dilating muscular bundles. In the horse, then, the dilating fasciculi appear to consist of precisely the same tissue as the sphincter, and to blend with it in their insertion. The flat bands of muscular tissue above spoken of seemed to have no special relation to the vessels, some of which were filled with injection. In the outer part of the iris of the same horse I found a delicate muscular fasciculus lying near but not intimately connected with one of the radiating vessels of this part. In the human iris I have seen a muscular fasciculus, as it appeared from the nuclei it contained, crossing the sphincter at right angles for a short distance; this observation, so far as it goes, seems to imply that the same mode of insertion of the dilator occurs in man as in the horse.

The fibre-cells of the dilator appear to be held together much more closely than those of the sphincter, at least in the outer part of the iris; for I have never been able to define the individual fibre-cells in a perfectly satisfactory manner in the dilator, though I have often teased out portions of the outer part of the iris. The dilating muscular tissue is also probably less abundant than the muscular tissue of the sphincter; and this, if the fact, will help to account for the comparative difficulty in discovering it. I may here mention that both in the cat and in the rabbit, soon after death, dilatation of the pupils being present, exposure of one iris to the air caused it to contract at once, while the pupil continued dilated in the other eye, which was untouched. I do not know if this fact has been observed before, but it is interesting in two ways—first, as showing that the muscular tissue of the iris, like other muscular tissue, is obedient to the stimulus of exposure; and, second, as proving either that the sphincter is in these animals a decidedly more powerful muscle than the dilator, which is equally exposed to the stimulus; or else that the fibres of these two muscles have different endowments, as has been shown by Mr. Wharton Jones to be the case with the muscular tissue of the arteries and veins of the bat's wing; where, although the veins are muscular, and even contract rhythmically, yet the arteries alone exhibit tonic contraction when irritated by mechanical stimulus.

A rich network of extremely fine fibres, seen readily in the blue human iris viewed from the anterior aspect, appears to represent the nerves of the organ. The fibres are of a yellowish colour, and are possessed of pretty high refractive power; they present, if really nervous, a good illustration of the division and anastomosis of ultimate nerve-fibres; the smallest divisions visible under a high power are seen only as fine lines.

I have not seen any nerves in the human iris presenting the double contour; but in the iris of a cat, so fresh that the tissue contracted under the needles as I teased it out, the double contour of the nerve-tubes was already very strongly marked, showing the existence in this animal of the white substance of Schwann in these nerves. The double contour surrounded the ends of the nerve-fibres which I supposed to have been broken by the teasing process. This last fact seemed to confirm the general belief that the double contour is a post-mortem effect, which, however, was in this instance a very rapid one.

I believe that a further investigation of the fresh blue iris in man, and of the horse's iris, would supply the means of finally settling the question of the distribution of the dilator pupillæ.

My engagements do not allow me to carry the inquiry further at present; and my apology for offering the results of an incomplete investigation is, that a contribution tending, in however small a degree, to extend our acquaintance with so important an organ as the eye, or to verify observations that may be thought doubtful, may probably be of interest to the physiologist.

Hints on the Subject of collecting Objects for Microscopical Examination. By GEORGE SHADBOLT, Esq.

HAVING procured a good microscope, it is often a source of perplexity to the novice to obtain a sufficient supply of objects on which to exercise its powers, although the real difficulty consists not in procuring enough, but in finding time to examine with proper care all that is readily obtainable. It must be admitted that the acquisitive powers, like all others, are materially improved by being exercised, and many good collectors in embryo remain undeveloped from the want of a little information to commence upon. The object I have in view is to offer a few hints to those who may happen to be deficient in this fundamental knowledge, especially as regards the means of finding Diatomaceæ, Desmidieæ, and other Algæ. Masses of water in all situations are generally to be examined for objects of this class.

Rivers, brooks, springs, fountains, ponds, marshes, bogs, and rocks by the sea side, are all localities that may be expected to be productive, some being more prolific than others, and the species obtained differing of course in general, to a certain extent, according to the habitat.

On considering the nature of some of the places indicated it will of course be apparent that in order to spend a day in collecting with any comfort, it will be necessary to make some provision for keeping the feet dry, for which purpose a pair of India rubber goloshes will answer, or better still a pair of waterproof fishing boots, but without one or other the work is by no means pleasant.

A dozen or two of small bottles made of glass tubing about half an inch in diameter and without necks, and from one to two inches in length, are the most convenient depositories for the specimens if intended ultimately for mounting; and it is advisable also to take two or three wide-mouthed bottles of a larger size, holding from one to two fluid ounces, an old iron spoon, a tin box, some pieces of linen or calico two or three inches square, a piece of string, a slip or two of glass with the edges ground, such as are used for mounting objects, and, lastly, a good and pretty powerful hand magnifier. Two Coddington lenses mounted in one frame of about half an inch and one-tenth of an inch in focal power are specially convenient.

Perhaps it will be as well in pointing out a few localities to describe some that I have actually visited, with the means of access, and the appearance of the various species *en masse* that I have met with.

Swanscombe Salt Marsh will be found well worth a visit, and it can be reached either by steamboat or railway from London Bridge to Northfleet. On quitting the railway station make towards the almshouses on the top of the hill, and arriving at the road turn to the left, descend the hill and cross a sort of bridge over a somewhat insignificant stream. Continue along the main road a little further until a point where it begins to ascend again, and diverges to the left towards the railway, here quit it, taking your course along an obscure road nearly in a direct line with the main one, passing a windmill on the right hand, and continuing until you arrive at another still more obscure road turning off to the right, which road appears as if made of the mud dredged from the bottom of the river and partially hardened. This is Swanscombe Salt Marsh, and the road just described leads towards Broad Ness beacon. On either side is a sort of ditch, one containing salt or very brackish water, the other filled with a sort of black mud, about the consistence of cream, the surface being in parts of a slaty grey with little patches here and there of a most *brilliant brown colour* glistening in the sunshine, and presenting a striking contrast to the more sombre shade. By carefully insinuating the end of one of the slips of glass under this brilliant brown substance and raising it gently, it can be examined with the Coddington, and it will probably be found to consist of myriads of specimens of

Pleurosigma (*Navicula* of Ehrenberg) *angulatum*, or *Balticum*, or some other species of this genus. The iron spoon now is useful, as by its aid the brown stratum, with little or no mud, can be skimmed off and bottled for future examination. On the surface of the water in the other ditch may be noticed a floating mass of a *dark olive colour*, which to the touch feels not unlike a lump of the curd of milk, and consists of *Cyclotella Menighiniana* and a *Surirella* or two embedded in a mass of *Spirulina Hutchinsia*, and another mass of floating weed which feels harsh to the touch, proceeding from a quantity of a Synedra, closely investing a filamentous alga, and elsewhere *Meloseira nummuloides* (*Gallionella* of Ehrenberg).

In a trench by the *sea-wall*, as it is termed, is a mass of brown matter of a shade somewhat different to any hitherto observed, adhering to some of the parts of the trench, being partially submerged, and having a somewhat tremulous motion on agitating the water. This is a species of *Schizonema*, and it consists of a quantity of gelatinous hollow filaments filled with an immense number of bright brown shuttle-shaped bodies, like very minute *Naviculæ*. It is not necessary to be particular about collecting the specimen free from mud, as the filaments are so tough that the mud can be readily washed away by shaking the whole violently in a bottle of water and pouring off the mud without at all injuring the specimen. The *Amphisporium alatum* communicates a somewhat frothy appearance to the otherwise clear water, and to get any quantity of this requires a little management, but by skimming the surface with the spoon, and using one of the larger bottles, an abundance may readily be obtained.

Between the sea-wall and the river the marsh is intersected in every direction with a number of meandering creeks, being in some places eight to ten feet deep, though in others quite shallow, but it is exceedingly difficult to make one's way amongst them, and I have never found them so prolific anywhere, on the few occasions of my visiting the place, as in the parts more away from the influence of the tide. It will be observed, from what I have stated, that the brilliant brown colour—of a deep but bright cinnamon tint—is one of the best indications of the presence of Diatomaceæ; and, though this is by no means universal, the variation is most frequently dependent upon the presence of something which qualifies the tint. The peculiarity of the colour is due to the endochrome contained in the frustule, and this must be in general got rid of before the beautiful and delicate markings can be made out; but it is highly advantageous and instructive to view them in a living state, and this should be done as soon as possible after reaching home with all specimens procured from salt-water localities, as they rapidly putrefy in confinement, and emit a most disgusting odour, not unlike that arising from a box of inferior Congreve matches.

Washing in fresh water, and then immersing in creosote water, preserves many of the species in a very natural-looking manner; but they are killed by the fresh water, and the endochrome becomes much condensed, in the *Pleurosigmata* and some other species. The addition of spirit quite spoils the appearance of the frustules, as it dissolves the endochrome.

There is another salt marsh a little farther down the same line of railway at Higham, which it would be well to explore; but as I have only paid it one visit, at the most unfavourable time of the year I could possibly have hit upon—the early part of December, I did not find many species there. I would observe that, as far as my limited experience extends, the most favourable months for procuring Diatomaceæ are April, May, September, and October, but some species are found in perfection as early as February, and many as late as November, and a few at all times of the year.

There is a piece of boggy ground near Keston, beyond Bromley in Kent, where the river Ravensbourne takes its rise, where many interesting species of Desmidieæ and other fresh-water algæ may be procured.* From Bromley walk on towards Keston, passing near Hayes Common and Bromley Common on the right. Continue for about another half mile along the road, and then turn to the right hand, pass the reservoirs, and approach an open space where there is a bog of about a quarter of a mile in extent, and, tending towards the right, make your way amongst heaths, ferns, mosses, and the beautiful *Drosera rotundifolia* (sundew), to the lower part of the little stream rippling through a sort of narrow trench in the *Sphagnum*, &c. By working your way *up* the stream you avoid the inconvenience, which would otherwise be experienced, of the water being rendered turbid in consequence of having to tread in the boggy ground.

In the centre of the little stream may be observed something of a pale pea-green colour flickering about in the current, which, on your attempting to grasp, most likely eludes you, and slips through the fingers, from being of a gelatinous nature. It consists of a hyaline substance, with a comparatively small quantity of a bright green endochrome disposed in little branches, and this is the *Draparnaldia glomerata*. Another object is a

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* An omnibus leaves the Elephant and Castle at half-past nine every morning for Bromley, which is the most convenient means of access to the spot.

mass of green filaments, rather harsh to the touch, very slippery; when viewed with a lens of moderate power each filament is seen to be surrounded with several bands of green dots, looking like a ribbon twisted spirally, and may be recognised as *Zygnema nitidum.* In various parts there are other species of *Zygnema*, *Tyndaridea*, *Mougeotia*, *Mesocarpus*, and many others. Keeping up the stream, and occasionally diverging a little on either side of it amongst the miniature bays and pools in the Sphagnum, on looking straight down into the water we shall probably see at the bottom a little mass of *jelly*, of a *bright green*, and studded with numerous brilliant bubbles of oxygen gas. This is the general appearance of most of the Desmidieæ, as *Micrasterias*, *Euastrum*, *Closterium*, *Cosmarium*, &c. &c. The spoon is also a handy tool in this case, though by practice the finger will do nearly as well, the chief difficulty arising when the specimen is brought to the surface of the water, it not being easy to get it out in either case without losing a considerable portion of it.

Little pools in the bog, made by the footsteps of cattle, are particularly good spots to find Desmidieæ, and I have frequently found many species in a very contracted space.

The most prolific bog I am acquainted with is at Tunbridge Wells, near a house known as Fisher's Castle, not far from Hurst Wood. There is also a good one at Esher, at a spot called West End.

It must not be imagined that nothing can be obtained in this department of botany without going some distance from town, but assuredly only commoner and fewer species can be met with nearer home. At the West India Docks I have found *Synedra fasciculata*, *Gomphonema curvatum*, *Diatoma elongatum*, *Diatoma vulgare*, *Surirella ovata*, &c. &c.; and, by the way, at this same place a few objects not of the botanical class, as *Spongilla fluviatilis*, *Cordylophora lacustris*, *Alcyonella stagnorum*, &c., are obtainable in abundance in the autumn.

In the Serpentine may be found *Cladophora glomerata* and *Sphæroplea crispa*, two of the filamentous algæ; and in the ornamental water in St. James's Park, *Cocconema lanceolatum*, and other species of this genus, *Gomphonema cristatum*, &c. &c. Epping Forest, about the neighbourhood of Leytonstone, Snaresbrook, Wanstead, and Woodford Bridge, are also capital localities for the filamentous Algæ, especially the last named, where *Nitella translucens* and *Chara vulgaris* abound.

In the fountains in the Surrey Zoological Gardens I have met with several species of Diatomaceæ and Desmidieæ at different seasons, including the genera of *Synedra*, *Gomphonema*, *Cocconeis, Stauroneis. Cymatopleura, Surirella, Pleurosigma,* &c., among the former, and *Closterium, Cosmarium,* and *Staurastrum* among the latter.

Hampstead Heath, although producing some of the above, is a place far more prolific in aquatic animalcules, even if we exclude the Volvox globator from this latter class, and reckon it as belonging to the vegetable kingdom.

Observations on the existence of CELLULOSE *in the Tunic of Ascidians.* By T. H. HUXLEY, Esq., F.R.S.

A CAREFUL examination of a number of species of the Ascidian genera *Boltenia, Cynthia, Molgula, Phallusia, Syntethys, Aplidium, Pyrosoma,* and *Salpa*—including, therefore, every modification of the type, has led me to the following conclusions with regard to the structure of the mantle. The investigation was made with a full knowledge of what had been done by Löwig and Kölliker and by Schacht (p. 34), and I have only ventured to differ from them upon strong evidence.

1. In the most gelatinous forms of the test, as in *Syntethys* and *Salpa,* it consists of a soft homogeneous or delicately striated basis, through which round nucleated cells (nuclei of Kölliker and Löwig) are scattered. These cells present no ramifications, and the presence of cellulose is demonstrated with very considerable difficulty. When the iodine solution is added the whole mass becomes coloured yellowish-brown, the nucleated cells taking rather a deeper tint than the rest. The addition of sulphuric acid slightly contracts the whole substance, and if used with care gives the edges the characteristic blue tinge. The cellulose is evidently diffused through the intercellular nitrogenous basis; for the first evidence of the operation of the sulphuric acid is seen in a slight diffused, even green shade, which is produced by the incipient blue re-action of the cellulose mingling with the existing yellow-brown colour. As the action of the test goes on, the edges of the membrane become deep blue, while the green tinge passes insensibly into the blue on the one side and into the yellow on the other.

As Schacht justly points out then, the substance of the test is not pure cellulose but cellulose deposited in a nitrogenous membrane. It exists in the same condition as the calcareous salts in bone, or as the chondrin in cartilage.

Substituting cellulose for calcareous salts, the structure of the test of *Salpa* is exactly that of the bone of plagiostomous fishes (Leydig, Beiträge zur Anat. d. Rochen. Haie, 1852).

2. *Pyrosoma* has a firmer test, which contains far more cellulose. This is more readily detected by the iodine and sulphuric acid, but in its relation to a general nitrogenous basis precisely resembles that of *Salpa*.

The nucleated cells differ from those of Salpa in being thrown into very long processes which meet and unite—just like those of Volvox as described by Mr. Busk. On the other hand they assume exactly the appearance of bone corpuscles—though the processes are generally straighter and are rarely branched.

Making the same substitution as before, we have in the test of *Pyrosoma* a structure comparable to that of the lamina papyracea of the ethmoid bone.

3. In the *Phallusiæ* there is an indistinctly fibrillated basis, containing a large amount of cellulose in all essential respects resembling the foregoing. Nucleated cells, provided with irregular processes, are scattered through this substance.

The large cells described by Löwig and Kölliker and by Schacht are not cells at all but are vacuolæ—very probably produced, like the cancelli of ordinary bone, by interstitial absorption. There is no lining membrane like that described by Schacht. With care the walls may be coloured deep blue to their very edges. The appearance of fibres is produced by the striation which runs through the whole mass, and is especially distinct upon the walls of the cavities. It exists after the action both of sulphuric acid and of caustic soda.

Lastly, the resemblance to perfect bone is completed by the canals which are hollowed out in the substance of the test for the vessels (or rather prolongations of the outer tunic, which is what they really are). In the walls of these canals I have frequently seen the nucleated cells projecting just as Kölliker describes them in the "medullary canals" of developing bone (Mikroskopische Anatomie, p. 369).

The spiral fibres described by Schacht are the muscular fibres surrounding the wider portions of the vessel-like prolongations.

Finally, with regard to the relations of the cells to the cellulose—anatomically and physiologically—I do not see any force in the distinction attempted to be established by Schacht between animals and plants. The nucleated cell of the Ascidian tunic answers exactly to the primordial substance of the plant. The cellulose is deposited *outside* both. The amount of nitrogenous matter mixed up with the cellulose deposit appears to be a mere question of degree—and the nature and existence of an intercellular substance in the vegetable kingdom are still matters too much disputed to be good grounds of distinction.

The physiological theory of Löwig and Kölliker, that the cellulose of the Ascidians is derived from the Diatomaceæ upon which they feed—is incompatible with the fact (Annals of Nat. Hist, Aug., 1852) that the larval Ascidian contains cellulose before any of its organs are developed.

To examine the test of an Ascidian for cellulose, I find the best way to be, to take a very thin section and moisten it with a strong solution of iodine in iodide of potassium. After being thoroughly impregnated with the iodine, the superfluous fluid should be drained off, and the segment carefully *blotted* with the finger [or hair pencil]. A handkerchief or blotting-paper may readily give rise to error by leaving behind small fragments of vegetable fibre. A drop of sulphuric acid, as strong as can be procured, should now be added. If much cellulose is present a deep blue colour will appear immediately, beginning at the edges of the slice; if there be but little, the colour will not appear for some time. The application of the test requires some care; and while its success is most valuable evidence of the *presence* of cellulose, its failure is not by any means negatively conclusive, unless the experiment has been frequently and carefully repeated.

TRANSLATIONS.

Description of ACTINOPHRYS SOL. By A. KÖLLIKER. From Siebold and Kölliker's Zeitsch., I. p. 198. 1849.

THE simplest forms in animated nature are to the genuine naturalist of great value and significance. Though wanting in the attractions derived from multiplicity of shapes, and although the investigation of their life is apparently without any immediate purpose of utility, yet do they hold out to the true philosophic inquirer an ample reward, and, from the paucity of means exhibited in them for the production of great effects, they are well calculated to charm and interest the mind. The solution in fact of general questions of the utmost importance depends upon a correct knowledge of the lowest organisms—such questions, for instance, as—What is an animal? What a plant? What an organism? or even, What is life itself? And when it is considered that these lowest forms are in great measure to be regarded as *simple cells*, an unprejudiced inquiry into the vital phenomena presented in them, becomes of daily greater importance towards a proper comprehension of the higher organisms, which are also in great part composed of cells.

Induced by these considerations, the author has pursued the investigation of certain of the lower forms of animal life. Some of the fruits of his labours have already appeared in a paper on the Gregarinæ, &c., and he now presents the following account of the Sun Animalcule—*Actinophrys Sol.*

I. *Anatomy of Actinophrys Sol.*—The form of the *Actinophrys* (figs. 1, 2, 3) is that of a depressed sphere; viewed on the flat sides, it is perfectly circular, and on the edge, elliptical. The surface of the body is universally and pretty closely beset with delicate tentacular filaments. The length of these filaments is at least equal to, or much greater than, the longer diameter of the animalcule; they arise from a rather wide base, and becoming gradually attenuated, though with frequent nodosities, terminate in an extremely fine almost invisible point.

The colour of the animalcule, independent of all foreign contents, is, to the naked eye, a dull white; when more closely examined, the interior usually appears whiter than, and to be rather sharply defined from, the transparent external portion; and this is confirmed upon microscopic inspection.

Measurements: the smallest individual that came under the author's inspection measured 1-38th—1-30th‴; the largest

1-6th—1-4th′′; the medium size was 1-8th—1-6th′′′; the filaments 1-6th—1-3rd′′′, or even ½′′′ long, and 0·0016—0 0006′′′ wide at the basis; the little nodosities upon them 0·007′′′ long, and 0·004′′′ wide.

The structure of *Actinophrys* has not hitherto been correctly understood by the greater number of observers. According to Ehrenberg ('Infusor.,' p. 303), it possesses a mouth with a proboscis and an anus, which are opposite to each other, and in the interior, numerous stomachs, on which account it is referred to the division Enantiotreta of the Enterodela or Polygastrica having an intestine. The older observers also, such as O. F. Müller and Eichhorn, are, to some extent, of the same opinion, as well as most modern zoologists, who simply adopt the statements of Ehrenberg. But Dujardin ('Infusoires,' p. 259) characterises *Actinophrys* as 'animaux sans organisation appréciable;' adding, in explanation (p. 260), that their body consists of a soft grumous substance, in which nothing can be observed but variously sized granules, and frequently very large vacuolæ. According to the author's investigations, Dujardin, in this instance, as in many others in which he has combated the views of Ehrenberg, is altogether in the right; for, although he was not acquainted with the vital phenomena of *Actinophrys*, he comes very near the truth in what he has observed of its structure.

Actinophrys, in fact, does not present a trace of mouth, stomach, intestine, and anus, consisting entirely of a perfectly homogeneous substance, of very soft and delicate consistence. Examined under a higher magnifying power (Plate I. figs. 1, 2, 3) the whole animalcule at first sight seems to be composed of the most regular and delicate tissue of round or polygonal cells; but on closer inspection it will soon be found that, in the usual sense of the term, there are not in reality any cells. On the contrary, it will be seen that what appears as a cell-membrane is not any special envelope, but that it is in continuous connexion with a pale substance, which in greater or less quantity occupies, like a sort of intercellular substance, the space between the supposed cellular cavities; and also that the numerous opaque granules are retained in this substance, and in no case contained in the cavities, which are filled merely with a clear aqueous fluid (figs. 1, 4).

When the animalcule is torn or crushed it becomes evident that it is entirely composed simply of a homogeneous substance with vacuoles, for it will be found that the supposed cells may, at pleasure, under pressure, be made either to coalesce into larger or be divided into smaller cavities, presenting in all respects the character of the normal ones. The only thing indicating the existence of cells is this, that in the innermost portions of the animal after it has been crushed, a few vesicular particles come into view, which, owing to the presence of an internal corpusule, more resemble cells. Under pressure these vesicular bodies may be readily isolated, they then behave sometimes as cells with nucleus and nucleolus, sometimes as free nuclei. The author is in fact inclined to regard them as cells and nuclei, lying in some of the interior vacuoles, for such, and such only, are the vesicular spaces in which they are inclosed, and will say more about their nature subsequently.

Disregarding, then, these adventitious elements of secondary importance, the entire *Actinophrys* is throughout composed of a simple homogeneous substance, with granules and vacuoles. In it may more or less clearly be distinguished two portions, a cortical and a nuclear. The former (figs. 1, 2, 3, *a*) is, on the average, 1-36th‴ thick, surrounds the nucleus, supports the tentacular filaments, and is more transparent than the nuclear (figs. 1, 2, 3, *b*), which presents the appearance of a flattened sphere of more or less white colour. Both portions possess essentially the same structure, and the difference between them depends upon the circumstance that, in the substance of the nucleus, there are many more granules than in the cortical portion. These granules are rounded, opaque, very minute (at most 0·0005″ or 0·001″), insoluble in acids or alkalis, and therefore probably of a fatty nature. The homogeneous substance of the body (figs. 1, 2, 3, 4, *c*), of a yellowish tint, is very soft, but highly elastic, so that an *Actinophrys* placed on a plate of glass in too small a quantity of water, becomes flattened out into a large and extremely thin disc, which, upon the addition of water, reassumes its original globular form ; it is rendered pale by acetic acid and cold potass, in which latter it gradually, but when heated, rapidly, dissolves, and it is therefore of a nitrogenous nature. The clear spaces or vacuoles (figs. 1, 2, 3, 4, *d*) are of pretty uniform size, 0·009—0·02‴, or in the mean 0·012‴ in diameter. In the cortical portion they are disposed in two or three tolerably regular layers ; but in the nuclear part, and especially towards the centre, they exhibit no definite arrangement, and are at the same time smaller and have more interstitial substance than in the cortical portion, where there is frequently only a thin lamella between two vacuoles. The peripheral layer of this fundamental substance is somewhat thicker, although still extremely thin, even where the tentacular filaments are given off from thicker parts of it. These filaments are in fact immediate prolongations from it ; they (figs. 1, 2, 3, 4, *e*) consist of the same substance as the rest of the body, from which they differ only in their never having vacuoles, and if granules, but very few of them.

II. *Physiology.*—As regards the *vegetative functions*, the mode in which the *Actinophrys* is nourished is of the highest and most special interest. *Although the creature has neither mouth nor stomach, yet it takes in solid nutriment and rejects what is indigestible.* This miracle, for so it may almost be called, is thus effected: the *Actinophrys* feeds upon infusoria of all kinds—minute crustaceans (Rotifera, minute species of *Lynceus*, the young of *Cyclops*, &c.), and the lower algæ (Diatomaceæ, spores of *Vaucheria*, *Closterium*, &c.). When, in its progress through the water, it approaches one of these little plants, or when an Infusorium has come into proximity with it, both plant and animal, as soon as they touch one of the tentacular filaments, usually adheres to it. Now as the filament with its prey slowly shortens itself, and the latter approaches the surface of the body, all the surrounding filaments apply themselves upon it, bending their points together so that the captive becomes gradually enclosed on all sides (fig. 2, *f*); according to all appearance these filaments also become more or less shortened. In this way the morsel is gradually brought to the surface of the body, the filament by which it was seized being finally so much shortened as to disappear altogether, and having, as not unfrequently happens, relinquished its hold upon the prey, after the latter has become encompassed by the surrounding filaments. These gradually apply themselves more and more closely together around it, forcing it towards the surface of the body.

The following proceeding now takes place:—The spot of the surface, upon which the captured animalcule is lying, slowly retracts and forms at first a shallow depression gradually becoming deeper and deeper (fig. 2 *f*), in which the prey, apparently adherent to the surface and following it in its retraction, is finally lodged. The depression, by the continued retraction of the substance, now becomes deeper; the imprisoned animalcule, which, up to this time, had projected from the surface of the *Actinophrys*, disappears entirely within it; and at the same time the tentacles, which had remained with their extremities applied to each other, again erect themselves and stretch out as before (fig. 2 *g*). Finally, the depression acquires a flask-like form by the drawing in of its margin (fig. 2 *g*), the edges of which coalesce, and thus a cavity closed on all sides is formed, in which the prey is lodged. In this situation it remains for a longer or shorter time, gradually however approaching the central or nuclear portion, and at last passing entirely into it in order to await its final destination. In the meanwhile the external portion of the Actinophrys regains in all respects its pristine condition. The engulphed morsel is gradually digested and dissolved, as is readily seen by its change of appearance from time to time. If entirely soluble, as, for instance, an infusorium, the space in which it is contained contracts as the dissolution of its contents goes on, and finally disappears altogether; should there be, however, an indigestible residue (a membrane composed of cellulose, a portion of chitine, a shell of a *Lynceus*, or case of a Rotifer, &c.), a passage for its exit is formed, and it is expelled by renewed contractions of the homogeneous substance, and in the same direction or nearly so as that which the morsel followed in its introduction. The passage and the opening through which the expulsion was effected disappears again without leaving a trace.

The above is a representation in general terms of the very curious mode in which the *Actinophrys* receives, digests, and rejects what remains of its nourishment. The following observations may serve to make it better understood. As regards the formation of the tentacular filaments it is stated by Ehrenberg, who at the same time assigns to them the duty of seizing the prey, that they exert a "rapidly fatal" influence upon the captured animalcule. This is incorrect. The author has very often seen infusoria which were adhering to the tentacles still in motion, and even when arrived near the surface of the body break away and escape; and in several cases he has observed very lively movements in animalcules which had been completely swallowed and imbedded in the cortical substance or in the nucleus. It would appear that the only action of the tentacles is to retain the prey by their adhesive surface, and probably to involve it also with their extremely fine extremities, and then that, by their mutual approximation, they continue to hold it fast, and at the same time by their contraction bring it towards the surface of the body.

In the second place, with respect to the non-existence of a mouth, stomach, and anus, no doubt whatever can be entertained. Without the slightest notion of the remarkable conditions he was about to find, the author approached the investigation of *Actinophrys* with a due belief, at least, in the existence of the mouth and anus, described by Ehrenberg. When he for the first time witnessed the process of reception of a morsel, he thought in fact that he had found the mouth in the depression formed on the external surface; and in the whitish nucleus into which the morsel was finally lodged, a large central stomach. But he was soon undeceived, for, by longer observation of one and the same individual contained in a watchglass he soon perceived that the supposed mouth disappeared again after the entrance of the morsel without leaving a vestige, whilst other observations showed him that the supposed stomach was a homogeneous substance, with similar cavities, and of the same nature as the cortical. Now as he had also ascertained the merely transitory existence of the anus, and, by steadfast consideration for hours together of different individuals, had also made the discovery that the *Actinophrys* employs the same part of the surface of its body at pleasure and temporarily as either mouth or anus—the mystery was cleared away, and views opened out which further investigation the more firmly established.

In the reception and rejection of the morsel, the manifestly contractile homogeneous substance of the body appeared to play the principal part. By its retraction in any part a hollow is formed into which the morsel enters; then the borders of the hollow approach and coalesce in consequence of contraction, and the morsel is within the body; new contractions, lastly, propel it from without inwards towards the nucleus, and at a later period serve again to expel the undigested remains. All these contractions are partial, taking place only in one or few spots at the same time, whilst at other places the substance of the body remains passive, yielding before the advance of the morsel. How the clear spaces are concerned in the penetration, advance, and expulsion of the food, it is difficult to see; they seem to disappear in places and to be reformed, though it cannot be altogether denied that they may merely separate from each other in order to make way for the entrance of the foreign body. It is especially to be remarked that the advance of the morsel into the body has the greatest resemblance with what is observed in unicellular infusoria, having a mouth, such as *Bursaria*, &c., when the morsel enters the soft contents of the cell, or the so-called parenchyma.

The number, as well as the size of the morsels, taken at one time by the *Actinophrys*, is very various. Very frequently there may be 2, 4, 6, at the same time—frequently also more than 10 or 12. Ehrenberg counted as many as 16 stomachs, which may be looked upon as so many separate morsels. He also noticed the ingestion of indigo, which could not have gained admission in any other way than that by which the infusoria and other aliment enter. The largest morsels noticed by the author consisted of a *Lynceus* or a young *Cyclops*. Eichhorn indeed mentions even a water-flea (*Daphnia?*), about the size of which, however, no remark is made.

The mode in which the nutrient morsel is digested is not clear. Every morsel, without exception, lies in a large vacuole, formed temporarily for its reception in a small quantity of clear fluid, of which it does not appear whether it comes from without, or is secreted in the interior of the animal and collected round the morsel. The food is digested in a few hours (2—6), and the indigested residue, together with the drop of fluid by which it is surrounded, is expelled. In this way the sharply defined drop, with the enclosed fæces, are pushed in an entire mass through the parenchyma of the body. Scarcely arrived at the surface, however, the mass breaks up and becomes dispersed, although the solid particles which had been included not unfrequently remain for some time as a granular body with irregular outline, as a greyish cloud, in the neighbourhood of the animal, until it is at last entirely dissipated.

Of the other vegetative phenomena there is not much to remark. Regarding the mode of growth, of the conditions attending which there is nothing to be seen, it might merely be remarked that individuals which have not eaten for some time present only a few granules in their parenchyma, and have a nuclear substance almost as transparent as the cortical; whilst, on the other hand, those containing numerous morsels of food, and consequently which are evidently better nourished, invariably present numerous granules. Hence it might with tolerable certainty be concluded that these (fat) granules are formed from the food, and during fasting are re-absorbed; probably, in general, they are constantly formed and removed as must in some degree be assumed to be the case with the fat of the higher animals.

In the Animal Sphere, the movements are especially deserving of all consideration. As the lowest animals in general, so does *Actinophrys* move entirely without the intervention of muscles or nerves; but besides this, it presents the peculiarity that the whole parenchyma of its body in all its parts, including the tentacular filaments, is contractile. All the motions of *Actinophrys* are performed with the utmost slowness, so slowly, in fact, that it is only by prolonged attention to one point, and still longer to the whole form, that it can be perceived. In the first place are to be mentioned the tentacular filaments, in which numerous changes of form, such as elongation, shortening, local swelling, bending, &c., may most readily be observed, whilst at the same time with them the scattered granules in their substance move here and there, although even in this case the utmost slowness is the rule; a quick movement is never seen. It is especially interesting to observe that the filaments, singly or together, frequently disappear entirely, entering at last, as it were by continued retraction, into the substance of the body, and leaving no trace of their former existence; and that they reappear with the greatest readiness and with tolerable rapidity (figs. 3, 4). This disappearance and reproduction must be regarded in the same light as the similar phenomena in *Amœba*, in which the processes, as is well known, are of a very ephemeral nature; the author has frequently observed the phenomenon, and particularly in the reproduction of the filaments, very clearly seen, how the homogeneous substance forming the periphery of the body was first elevated into minute warty eminences (fig. 4), which soon become papillary (the 'proboscis' of Ehrenberg is probably nothing more than one of such papillæ), then conical, and are finally produced into a long filament. Whether the filaments which disappear are always reproduced in the same spot is not determined; in some instances this did not appear to be the case, although in every instance the number and position of the filaments is pretty constant. *Actinophrys*, not merely in the form of its processes, and their slow movements, but also in this respect, differing altogether from *Amœba*.

In the rest of the body itself, movements are well and clearly perceptible only in the reception and expulsion of the food and its remains. Otherwise only the most faint indications of contraction are apparent in it, such as a slight undulation of the border and inconsiderable quivering motions here and there. The creature also seems to be capable of altering its entire form to a certain extent, and to be able to expand and again contract itself *in toto*. More extensive and more energetic movements do not occur at all, and the author consequently is altogether ignorant as to how locomotion of the animal is effected. That it is active in this respect appears to be indubitable, for it was found, for instance, that when a vessel with several individuals of Actinophrys was emptied into a flat glass capsule, they were all at first scattered about at the bottom, but subsequently, after about twelve to twenty-four hours, were all floating at the surface, and indeed at the side of the capsule. Ehrenberg and Eichhorn assert that the ascension in the water of *Actinophrys* is effected by the taking in, and their descent by the giving out, of air. But this is certainly not the case, for whence could they obtain this air? Can it be said that they secrete it within themselves like fishes? In that case it must be visible. It appears to the author more natural that the rising and sinking should be effected by alternate contractions and expansions of the whole body. Other motions can affect both the filaments and the body, but in any case only through the slowest possible contractions.

Pulsating spaces, of which Siebold* describes two, immediately under the integument in *Actinophrys*, were never seen by the author, in as far as Siebold means such spaces as appear and disappear. If, on the other hand, he means only expansions and contractions of the substance bounding the vacuoles, but not such as to cause their disappearance, I entirely agree with him, and have seen, as is stated above, not two such only, but several.

Sensation also must certainly be assumed to exist in Actinophrys, only in it, as in the lower animals generally under this term, nothing like the conscious sensibility of man is to be understood; but rather, if a comparison must be drawn, may it be considered to resemble the condition present in the spinal chord and in ganglions, when reflex excitement in them is produced through nerves of sense.

Actinophrys perceives mechanical influences, and reacts upon them by movements. This is proved by what takes place when animalcules, &c., remain affixed to its tentacles, and moreover by the circumstance that when the water in which it is contained is carelessly agitated, every Actinophrys contracts its tentacles, and even makes them disappear altogether, and, indeed, with greater speed than is otherwise perceived in these creatures, and when all is quiet they are again protruded. These filaments consequently may just as well be called tactile as prehensile; or it may more generally be said that the substance of the body is both contractile and sensitive.

Under the head of the Reproduction of *Actinophrys*, the author's observations are extremely defective. Eichhorn and Ehrenberg would seem to have observed spontaneous fission, but it is not said whether these observers concluded that this takes place only from the occurrence of individuals apparently partially divided, or whether they have actually witnessed the production of two individuals from one. This is much to be regretted, since, as will be apparent, partially divided individuals of *Actinophrys* by no means demonstrate the existence of fission in this case. The author saw what follows:—Upon persevering inspection of a biscuit-shaped individual in which from analogy he expected to see nothing but that it was soon about to undergo division, he was not a little astonished to see it gradually assume an oval form, and finally to become a single individual. At first he placed no importance on this observation, and thought merely that his inquiry on the subject of reproduction had miscarried, but as he soon afterwards again noticed the same thing in a second individual, the matter appeared too remarkable to be passed over. He adverted to

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* Verg. Anat., pp. 20, 22.

the conjugation of the lower algæ, and devoted himself specially to the investigation of this point.

After some time thus engaged, he succeeded in one case in observing through all the stages of the process "the complete fusion into a solitary larger animal, of two individuals, originally perfectly distinct." The resultant individual was in no respect different from other single individuals, and it presented no trace whatever of its having been formed out of two. He was now very anxious to know what would become of it, and actually observed it for a whole day without noticing anything peculiar with respect to it. He then lost it by accident, and was otherwise, also, unable, as he was obliged to discontinue his observations, to follow the thing further; and he has been obliged to leave the question undetermined whether or no the fusion of two animals into one has anything to do with their propagation. Of other facts connected with this subject, it may be mentioned that the smallest individuals measured only 0·01‴—0·02‴, and presented very inconspicuous and few vacuoles, and secondly, that, perhaps, the above-described granular and vesicular corpuscles within the nuclear portion of the body might be germs just beginning to be evolved. Whether this is the case, must be left to future observation to decide; but so much must be remarked, that *multiplication by means of germs generated in the interior indubitably occurs in certain Infusoria;* the author has noticed in *Euglena* 4—6 embryos in one individual, and entirely filling it, which at last, furnished with their red point and cilia, broke through their parent, leaving it an empty case.

[To be continued.]

On the Microscopical and Chemical Examination of the Mantle of certain ASCIDIANS. By DR. H. SCHACHT. Müller's Archiv. 1851. p. 176.

IT is known that a substance having the chemical relations of cellulose was first shown by C. Schmidt (Zur vergleichenden Anatomie der wirbellosen Thiere, 1845, p. 61) to exist in the mantle of certain Ascidians; and the fact was confirmed by the chemical and microscopical researches of Kölliker and Löwig (Ann. d. Sc. Nat., 1846, p. 193), who extended their valuable observations over a great number of genera and species. Both Schmidt, Kölliker and Löwig proved the existence of the cellulose only by chemical analysis, but not by the application of re-agents under the microscope; they found in the mantle of the Ascidians a substance not affected either by hydrochloric acid, or by caustic potass, and which, after this treatment, being heated with potass, gave out no ammonia, and was consequently free from nitrogen.

According to the latter observers the substance consisted—

	In Phallusia mamillaris:	In Cynthia papillata:
Of Carbon	43·40	43·20
Hydrogen	5·68	6·16
Oxyden	51·32	50 64

According to Schmidt, in *Phallusia*, 100 parts contained—

Carbon	45·38
Hydrogen	6·47

The microscopic examination was made by Kölliker and Löwig, both before and after treatment of the mantle with hydrochloric acid. The form, and, for the most part also, the external condition of the mantle remained almost unchanged under this treatment, except that in *Cynthia*, the exterior coriaceous layer became smoother and more flexible. According to them, but in opposition to Schmidt's supposition, the Polypes and Medusæ contain no cellulose.

The methods I have followed in my investigation, though different from those pursued by him, yet serve in general to confirm Kölliker's observations; but since my researches appear to afford further information on some not unimportant points, particularly with respect to the condition of the cells in the mantle of *Phallusia*, and the fibres in that of *Cynthia*, I feel justified in communicating their results.

I examined thin, longitudinal, and transverse sections of the mantle, first in water and afterwards in succession under various chemical re-agents, such as a solution of iodine, a solution of iodine in chloride of zinc, iodine and sulphuric acid, solution of caustic potass, concentrated sulphuric acid, &c., in exactly the same way as that in which I had already examined all vegetable tissues. The species examined were—*Phallusia mamillaris*, *Cynthia microscosmus*, and a new species, probably allied to *Cynthia*, from Chili.

I. *Phallusia mamillaris.*—In the mantle of this Ascidian, according to Kölliker and Löwig, there are three layers perceptible,—an internal, consisting of an epithelium with cell-nuclei; a middle layer, which in a homogeneous substance contains crystals and cell-nuclei; and a third layer, which forms the chief substance of the mantle: numerous, much ramified vessels proceeding from the heart penetrate the latter, and which, at the surface of the mantle, appear to pass into other vessels which accompany them in their course. The elements of this layer are large, elegant cells, imbedded in a clear homogeneous substance, continuous with the principal substance of the second layer. The largest of these cells, measuring on the average 0·02—0·03‴, and which were regarded by Wagner as cartilage-cells, according to Kölliker and Löwig, correspond with no animal cells hitherto known, except those of the chorda dorsalis of some animals. After treatment with potass, the epithelial cells, the nuclei, and the pigment-cells, which occur here and there, disappear, together with the vessels; whilst, on the contrary, the substance of the second layer and the corresponding substance between the cells, together with the latter, remain undissolved. Kölliker and Löwig therefore regard both the substance in which the nuclei and cells lie, as well as the membrane of the cells itself, as non-nitrogenous—as cellulose.

The fleshy verrucose mantle of *Phallusia mamillaris* also, according to my investigations, presents the three layers above described. The innermost layer is separable as a thin membrane from the rest of the substance of the mantle; upon it lies a layer of very regular epithelial cells, a true tesselated epithelium, the cells of which still exhibit traces of a nucleus. This membrane itself is coloured blue by iodine and sulphuric acid, and is of a fibrous structure, with scattered nuclei; the epithelium acquires a brown colour. When boiled in caustic potass, the membrane contracts, without being dissolved, however; and when torn in this condition, its fibrous structure becomes still more evident. The epithelial cells disappear under this treatment. Upon or beneath this membrane lie, scattered here and there, large cells with granular contents, which, when warmed, does not become fluid, and therefore cannot be any readily congealed fat. When these cells are ruptured the substance breaks up into granular portions; I regard them as pigment-cells.

The second layer, demonstrated by Kölliker and Löwig, constitutes about 1-6th of the entire thickness of the mantle; it passes insensibly into the main layer; the principal vascular trunks lie in this layer, and in it they give off branches which ramify in all directions as far as the border of the mantle. The chief vascular trunks which enter the mantle in a radiating manner from one point of the animal (according to Kölliker, the heart), exhibit in their interior spirally ascending fibres, whence they resemble the tracheæ of insects; this structure does not exist in the smaller branches. The substance in which these large vessels are placed is homogeneous, with numerous elongated and round nuclei, but here and there there is a minute isolated cell, and still more rarely a group of crystals. Immediately under the readily detached epithelial membrane, the substance appears in places to be striated (fibrous), and after boiling with caustic potass this appearance becomes more distinct. The entire substance of this layer is coloured blue by iodine and sulphuric acid, the nuclei and vessels turning yellow; on being boiled with caustic potass the two latter are dissolved, the substance itself contracts, but is not otherwise altered; concentrated sulphuric acid dissolves it almost entirely. The third layer, which constitutes four or five-sixths of the thickness of the mantle, commences very insensibly below the large vascular trunks: it is at first distinguishable by the appearance of cells and the diminution of the cell-nuclei, which latter acquire a more irregular, frequently stellate figure, and in this condition strikingly resemble the bone-cells. The number and size of the cells increase in proportion to the diminution of the nuclei; the cells, which, at the commencement of the layer were more elongated, become more and more rounded, and more closely aggregated, but still not so much so as to interfere with their spherical form. At the outermost border of the mantle the cells again become somewhat smaller, which is best seen by boiling a portion of the mantle from this situation, in caustic potass. The external surface of the mantle is irregularly beset with short blunt columns composed of crystals; these crystals are insoluble in hydro-chloric acid; sulphuric acid appears to attack them but very slowly. They cannot therefore well be carbonate of lime, as supposed by Kölliker and Löwig. The outer surface of the mantle, like the inner, is covered with a tesselated epithelium, but the existence of this epithelium is here much more difficult of demonstration, and it does not seem to be retained in all parts. It is most certainly seen in thin horizontal sections on the addition of sulphuric acid. In the middle, and on the outer border of this layer, the nuclei are proportionately rare; the much ramified branches of the large vessels extend as far as the border of the mantle, where they terminate in clavate dilatations. Sometimes, it is true, it appears as if one or other branch of these vessels ran backwards into the substance of the mantle, but a double vascular system, as described by Kölliker and Löwig, I have nowhere been able to detect.

In a very thin section, under water, a peculiar, excessively delicate marking is perceptible in the thin cell-membrane, surrounded by the transparent interstitial substance, which marking in some cases might be taken for a closely wound spiral, but which, as I have satisfactorily ascertained, depends upon a folding of the membrane, due in all probability to the influence of the spirit in which the specimen had been kept. The form and appearance of the cells is the same in whatever plane they are viewed; they are not placed at any uniform distances apart. At the boundary between this and the second layer the formation of new cells appears to take place in the interstitial cellulose substance, without the intervention of a mother cell. The cells are invariably without a nucleus or any visible cell-contents.

Iodine colours the thin, somewhat granular-looking membrane of the cells in question yellowish, and the above described marking appears then more distinctly, and minute opaque granules show themselves in the furrows between the folds. The interstitial substance in thin sections is scarcely coloured; in thicker it appears yellowish.

If a thin section be touched with a solution of iodine, which is afterwards removed with a fine hair pencil, and a drop of sulphuric acid added by means of a glass rod, the section is immediately coloured a dark blue. It is not the cells which are coloured blue but the insterstitial substance. The thicker parts of the section do not acquire the blue colour till afterwards, frequently not for several hours.

If, on the other hand, a similarly thin section be moistened with the solution of iodine in chloride of zinc, the interstitial substance remains colourless, even when the section has been previously allowed to dry upon the glass. The cellulose of plants on the other hand, in general, if not immediately, yet after some time, appears to be coloured a beautiful blue or violet by this re-agent. The cellulose of the higher Algæ (*Chordaria*, *Fucus serratus*, *Chondrus crispus*) behaves in this respect like that in the mantle of *Phallusia*, and is not coloured by the ioduretted solution of chloride of zinc.

If to a thin, scarcely moist section, be added a drop of concentrated sulphuric acid, and its action noted, it will be seen to take place from the edge of the section towards its centre; the membrane of the cells contracts, and the markings, caused by the folds, disappear, though the minute granules contained in the furrows remain. The cell-membrane exhibits precisely the same re-actions as does the primordial sac of the vegetable cell. In proportion to the contraction of the cells the interstitial substance swells out, by which the distance between the cells is increased. The swollen interstitial substance is not optically recognizable. If now a drop of a solution of iodine be added, and allowed to enter from the side between the slips of glass, there appears at the limits of the intermingling fluids a brownish violet zone of a granular consistence as seen under the microscope. The solution of iodine is prevented by the swollen interstitial substance from penetrating farther, but if the cover is raised and again let fall after the solution of iodine has become mixed with the sulphuric acid, the whole assumes the appearance of a more or less clear, and more or less intensely blue membranous substance—the swollen interstitial substance—in which the almost imperceptible remains of the cells are lodged.

If a thin section be treated with sufficiently strong hydrochloric acid, there ensues, even after several hours, no colouring or other perceptible change either in the cell-membrane or in the interstitial substance, nor have I ever succeeded by the use of sugar and sulphuric acid in producing a manifest rose-red colour in the probably nitrogenous cell-membrane.

If a thin section be warmed for a minute in sufficiently strong solution of potass, it is not disintegrated; the membrane of the cells disappears entirely if the section were thin enough, and the re-agent has acted sufficiently; the interstitial substance becomes somewhat contracted; the hollows in which the cells had been contained on this account appear smaller. The addition of a solution of iodine now colours the interstitial substance yellowish, in an hour clear brown-violet; a fresh addition of the iodine solution exalts this colour; after twenty-four hours the section appears red-brown, like the colour of burnt terra de Sienna. Ioduretted chloride of zinc solution immediately colours a section that has been boiled in potass of a beautiful violet blue.

If small pieces of the mantle be macerated for 2½ to 3 minutes in chlorate of potass and nitric acid, the substance during maceration assumes a citron yellow colour, which disappears on the addition of water. The substance is not disintegrated, and may be cut just as readily after the maceration as before it; nor is any change perceptible under the microscope either in the cell-membrane or interstitial substance.

If, however, thin sections of the mantle are macerated in the same way for only a minute, the section does not become corrugated, assumes a yellow colour during the maceration, which disappears in water. The interstitial substance has not, as on the application of caustic potass, become contracted, the cells have not disappeared, though less distinctly marked than before; their membrane appears, as previously, rather granular, nor is it changed in the folds. The addition of solution of iodine scarcely produces a yellow colouring of the cell-membrane, the interstitial substance is not coloured, nor does the ioduretted chloride of zinc solution produce any effect—no blue colour being elicited even after several hours. Iodine and sulphuric acid however produce precisely the same blue colour of the interstitial substance as before the maceration; the pieces of the mantle which had been macerated 2½ to 3 minutes behave in exactly the same way towards the same re-agent.

[To be continued.]

REVIEWS.

LECTURES ON HISTOLOGY, delivered at the Royal College of Surgeons of England, in the Session 1850-51. By JOHN QUEKETT. London. Bailliere.

AMONGST the many admirable arrangements of the College of Surgeons in London is the delivery by the Professors of courses of lectures on what may be called the science of organization. In the lectures delivered by Professors Owen, Paget, and Quekett, the object of the College of Surgeons in relation to the profession of surgery is not lost sight of, but they have the higher object in view of illustrating the great museum which the industry of John Hunter commenced, and of exhibiting the spirit in which that profound genius laboured to unfold the laws of organization. Already science is deeply indebted for the contribution which the publication of many of these lectures has made to its literature. We may name more especially the philosophical lectures of the Hunterian Professor on Comparative Anatomy, as amongst the most important works of the day upon the subject.

It was not to be expected that the Council of the institution that was entrusted with the charge of John Hunter's museum would neglect the opportunity which recent improvements of the microscope afforded, of prosecuting by its aid the researches which that great philosopher had commenced. It was fortunate that in Mr. Quekett they found a man whose tastes, habits, and education peculiarly fitted him for prosecuting inquiries with this instrument. Unbiassed by the views of others, not given to speculation, delighting in delicate manipulation, and possessed of a patience unwearied as long as new subjects were to be examined or new facts observed, he was just the man to contribute to the histological parts of the museum, and to demonstrate the minute anatomy of the tissues. Under his superintendence the histological demonstrations became speedily popular, and as the result, his remarks on the preparations submitted to his class have been published in the form of these 'Lectures on Histology.' This title might however mislead, as this work is not a complete treatise on histology, nor intended to embrace the whole of this wide field of science. They consist of a series of remarks with reference to objects and preparations which were intended to illustrate a particular series of facts. The object of the present volume is the elementary tissues of plants and animals, and even these are not treated at all in an exhaustive manner. The work therefore must not be regarded as a manual or outline of the subject of histology, but as the remarks of an observer whose opinions are always of value, over a wide and important field of microscopic research.

The first part of the work is devoted to the tissues of plants, the second to the tissues of animals. We are glad to find that Mr. Quekett has devoted so much space to vegetable tissues, as there can be no doubt that the best introduction to the more difficult problem of cell-growth in animals is the study of the phenomena presented by the cells of plants. The vegetable and animal kingdoms, with a wonderful distinction in form and functions, have yet relations so close, and a dependence so absolute, that the principles which regulate the growth and functions of one cannot be understood without reference to the other; and researches, prosecuted by the aid of the microscope, are every day increasing our knowledge of the details of this great fact.

Mr. Quekett commences with an account of the old "elementary tissues" of the botanist, "membrane and fibre." It should, however, be recollected, that amongst plants there is no membrane, as there is in some animal structures, independent of the cells. The vegetable membrane referred to here is simply the cell-wall, which varies very much in form and properties in different cells. So with fibre. We well know there is no fibre independent of cells, and fibre is but one form which the deposits in the interior of cell-walls exhibit. There is no advantage to be gained in treating of these subjects independent of the cells in which they are found.

From a chapter entitled 'On the Forms of Cells,' in which several of the principal forms of plain cellular tissue are noticed, we pass to the contents of cells. Under the head of 'Starch' we find the properties of the common forms of this substance alluded to. Mr. Quekett adopts the term "hilum," as applied to the circular spot seen in the majority of starch granules; but this term is objectionable, as involving the idea of the attachment of the starch granule to the cell, which is not the case. Fritsche's term nucleus is better when this spot is obvious. This nucleus is mostly seen to be surrounded by curved lines, and which have been supposed to indicate that the starch is composed of a series of layers which have been consecutively deposited. Mr. Quekett however decides this, and says "they are confined to the cell-wall, and are most probably mere transverse thickenings or rugæ in the membrane, of which, together with its amylaceous contents, the starch-granule consists." This statement is at variance with the observations of Payen and Persoz, and of Schleiden, who maintain not only that the starch-granule is composed of several layers of differing density, but that there is no enveloping membrane, the whole granule consisting of a homogeneous mass. Schleiden says most emphatically, as the result of a long series of experiments on the action of iodine, that "there never was the most remote indication of there being any part in the starch-granule which was not equally coloured by it."

Speaking of the potato disease Mr. Quekett says:—

> "Before leaving the subject of starch, allusion may be made to the recently prevalent and destructive epidemic among the potatoes, which I believe to have been a disease of the tuber, not of the haulm or leaves. Examined in an early stage, such potatoes are found to be composed of cells of the usual size, but they contain little or no starch; and hence it may be inferred, that the natural nutriment of the plant being deficient, the haulm dies, the cells of the tuber soon turn black and decompose, and fungi are developed as on most other decayed vegetable substances."

This will undoubtedly explain the most prominent symptom of the potato disease—the tendency to decomposition,—and is a point in which the microscope confirms the result of chemical experiment, for it has been found that the diseased potatoes contain a larger proportion of water than those which are healthy. A want of organizing power is evidently the cause of this deficiency of starch, but we fear the microscope will never tell us in what the want of this organizing force consists.

Under the head of raphides there are some interesting remarks, but as in the portion of the Transactions of the Microscopical Society, which we publish in this Number, Mr. Quekett enters so fully into this subject, we shall pass it over, only observing that we cannot agree with him that they are accidental bodies. In many of the plants referred to, these bodies are constantly found, and we question if a specimen of any of them could be found in which these bodies are absent. Although Mr. Quekett has separated silica from the raphides, we cannot but think that the deposits of this substance in the tissues of vegetables are of the same nature as that of other inorganic compounds. It is true that the function of silica, as deposited in the stems of grasses, palms, and Dutch rushes (Equisetaceæ), is more obvious than that of oxalate of lime in the roots of rhubarb, but the one is not less constant than the other. In the family of Corallines we find carbonate of lime not less necessary to their existence than the silica of the Diatomaceæ. What the relation of these inorganic matters to the tissues of plants really is, may be seen in the perfectly analogous deposit of the same substances in the Polypiferæ and Spongiadæ in the animal kingdom.

In allusion to the distinctions between the Diatomaceæ and Desmideæ, Mr. Quekett says that the latter have a horny, in place of a siliceous structure. The horny character, however, of the Desmideæ is not dependent on gelatine but on cellulose, as we have frequently observed, by the application of sulphuric acid and iodine, when the cellulose is converted into starch and coloured blue by the iodine.

The use of the Diatomaceæ as food as they occur in the Berg-mehl of Sweden, seems to be regarded by Mr. Quekett as dependent on the silica they possess. We think it is much more likely to be on account of the layer of organized matter by which their siliceous skeletons are surrounded, and if we mistake not, this is the explanation given by Ehrenberg, who first demonstrated the true nature of this interesting substance. The part performed by Diatomaceæ in the creation is not yet fully understood. Of all organisms they are most abundant. Dr. Hooker found them discolouring the seas of the South Pole, and in the lava of the volcanic mountain Victoria. They are found in the greatest abundance in rivers, lakes, ponds, and ditches, and if in the purest water an organic being or two are found to be present, they are sure to be Diatomaceæ. The late Mr. Edwin Quekett discovered a highly interesting set of forms of them in the guano of Peru, and his brother suggests that this manure may owe something of its value to the siliceous matter which it thus contains. We have much to learn with regard to the history of these beings, the existence of which the microscope alone informs us, and we are glad to know that we are shortly likely to have the results of several years' careful examination of them from the Rev. Mr. Smith. Messrs. Ralfs and Jenner have also been labouring at this department of inquiry, and have partly promised a work on the subject, through the means of the Ray Society.

Under the head of 'Sclerogen,' Mr. Quekett has given a number of examples of those forms of cellular tissue in which the cell-walls are of unusual thickness and hardness. A knowledge of these is not only interesting, as illustrative of the great variety of cell-growth, but is not unfrequently of practical value, as the following cases prove :—

> "A knowledge of these hard structures is often of considerable importance, much more so, indeed, than many are apt to imagine. The following is an example of the practical utility of such an acquaintance with minute structural anatomy :—About two years since, I received from a medical gentleman in the country, some specimens mounted as micro-

scopic objects, that had been passed from the bowels by a female. One of them I found to be the cuticle of a plant, and this turned out subsequently to be the cuticle of a gooseberry; the other puzzled me, but I made up my mind that it also was of vegetable origin, and that it was, in all probability, the testa of some seed. I wrote to my correspondent to this effect, but the patient denied having eaten any dried fruit for the space of twelve years, and the physician, believing the statement of his patient, considered that the microscopist was in error. I, however, still maintained my point, and when preparing the series of specimens known as hard tissues, for the Histological Catalogue of the College of Surgeons, I examined, among other things, the tamarind, and in the testa of the seed found the disputed structure. I subsequently learned that the patient was the daughter of a grocer, and might have had free access to the tamarind jar. This is another instance of the value of the microscope to our profession."

Vegetable physiologists would have been glad of Mr. Quekett's opinion on the structure of the embryo, and especially on the question of the entrance of the pollen-tube into the sac of the embryo. He has not, however, alluded to this subject. He has, however, some remarks on the structure of Spermatozoids or Phytozoa, which are now known to exist in so many of the Cryptogamia. He has not examined these extensively. Although he has not alluded to the movements of these bodies as dependent on ciliary motion, there is no doubt that in the ferns at least they are supplied with cilia, which produce their movements. This subject is one which still offers a rich field of investigation for the microscopic observer. To those who wish to pursue this subject, we would recommend Dr. W. Hofmeister's work on the Germination, Development, and Fructification of the higher Cryptogamia. (Vergleichende Untersuchungen der Keimung, Entfaltung, und Fruchtbildung höherer Kryptogamen, 4to., Leipsic, 1851), and also the excellent report on this subject by Mr. Henfrey in the last volume of the Transactions of the British Association.

From plain cells and their contents we come to fibro-cellular tissue, to plain vascular tissue, such as that which is called woody, and the various forms of fibro-vascular tissue. In his treatment of these subjects the Professor has not followed any definite plan. All vegetable tissue is a modification of the cell, and any classification artificial. For practical purposes the term vascular may be applied to cells or tissue longer than it is broad, whilst cellular should be confined to tissue that is not longer than it is broad, and they may each be called fibro-vascular and fibro-cellular, as they present fibrous deposits, or their modifications in the interior. In speaking of the vegetable tissues used in the arts, Mr. Quekett has pointed out how the microscope may be successfully employed in distinguishing the various kinds of woody fibre used in the manufacture of clothing. The microscope may thus be made to throw light on the habits and manners of nations of antiquity. Thus it has shown that all Egyptian mummy-cloth is made from the fibres of the flax, whilst it has demonstrated that the mummy-cloth of Mexico is cotton ; thus at once throwing a light on the habits of the ancient inhabitants of the New and Old World; the one being engaged in the culture and manufacture of cotton, the other in that of flax.

The analogy between the structure of spiral vessels and the tracheæ of insects has not been lost sight of, and some interesting instances of both are given. Similar as these things appear we very much question if their mode of development is the same. They afford interesting examples of a principle which we often see carried out in nature of the greatest amount of strength with the least amount of material. The importance of this in insects will be at once felt when we reflect that many of them spend the greater part of their existence suspended in the air by means of their wings. We also find the spiral vessels of plants in positions where the same principle can be clearly seen to be of advantage. Whatever may be the resemblance in structure between these two parts there is no reason for supposing an identity of function. Reasoning from analogy of structure to that of function is always very unsound, for even amongst structures that are homologous we frequently find variety in the functions performed. Take the wings of a bird and the upper extremities of man, the swimming bladder of the fish, and the lungs of the mammalia.

In the section on spiral vessels Mr. Quekett mentions a fact that we do not remember to have seen previously noticed, the existence of membrane that tears up and unrolls in a spiral manner. This has been observed in the hairs found on the outside of the fruit of *Cycas revoluta.* There is one other subject we would allude to before leaving the botanical section, and that is the lactiferous or milk-vessels of Schultz. The branched character of these vessels makes them quite exceptional amongst vegetable tissues. It has been asserted that they are not true tissue at all, but are intercellular passages which have acquired the appearance of vascular walls from the deposits of the fluids which pass through them. At any rate we know little or nothing of their development, and this is a subject open for investigation at the present moment.

This part of the work concludes with the following sentence :—

> "One great object which I have kept in view throughout, has been that of endeavouring to impress on you the fact, that each cell of a plant should be considered as having an independent or individual existence ; that in one situation it may secrete colouring matter, in another starch, gum

sugar, oil, &c.; and in another the material for the reproduction of its species."

We are convinced that too much importance can scarcely be attached at the present day to the study of the cell as an individual. Many of the theories of vegetable function which have been hitherto received will not bear the test of an accurate knowledge of the functions of the individual cell. The young vegetable physiologist cannot do better than commence his studies, microscope in hand, with observations on the development and functions of the individual cell.

Want of space compels us to stop here: we shall probably recur to the remaining part of Professor Quekett's work in our next number.

Das Mikroskop, und seine Anwendung, &c. (*The Microscope and its application, especially to Vegetable Anatomy and Physiology.*) By Dr. HERMANN SCHACHT. Berlin. 1851. Pp. 200.

THE deservedly high reputation of Dr. Schacht as an accurate microscopical observer and excellent phytologist, and which has recently been much enhanced by his recent work on vegetable histology,* renders a book on the microscope and its use, from his hands, well worthy of consideration and respect. The limited scope of the present work, which is confined almost exclusively to botanical subjects, is much to be regretted. Had a chapter or two, having reference to the modes of procedure to be adopted in the investigation of animal tissues and other subjects, and in the same precise and satisfactory style, been added, the work would constitute a very complete and comprehensive manual of microscopy. The subject, however, to which it is more particularly devoted—the structure and development of vegetable tissues—is in itself one of great general interest and importance, and the author's treatment of it such as to justify our highest commendation.

After a few sensible introductory remarks on the use of the microscope in general, and the difficulties at first attendant upon its employment, the author proceeds to a description of the compound microscope. As, however, he appears to be familiar only with instruments of continental make, and to be altogether unacquainted with any of English construction, and consequently with many of the more recent improvements, introduced chiefly by English makers, not only in object-glasses, but more especially in the various modes of illumi-

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* Die Pflanzenzelle. Die innere Bau und das Leben der Gewächse. Berlin, 1852. Pp. 472.

nation, which have latterly occupied so much and so deservedly the attention of opticians, it is not necessary farther to refer to this part of his work than to observe that he gives the preference, above all other continental instruments, to the larger microscope by Oberhauser of Paris. This much-vaunted instrument we have not seen, but, from the description and figure of it given by Dr. Schacht, its very great inferiority, in the mechanical arrangements of the stand at all events, to those of our London makers, is at once apparent.

One result of the Great Exhibition of last year was incontestably to prove the superiority of English microscopes; and it is clear also from Dr. Schacht's observations,—and he boasts of an extended acquaintance with the microscopes of nearly all continental makers of any eminence,—that what he considers an instrument of the best possible kind would in most respects here be regarded in a very different light. So much in justice must be said on the part of English opticians. Can the same favourable comparison be drawn between English observers and their continental brethren? In some respects, and especially, perhaps, with reference to animal physiology, anatomy, and pathology, we are inclined to think it might, in others certainly not; but in any case it should not be forgotten that the extreme convenience, elegance, and, as it may be termed, luxury, of a first-rate English microscope, are quite unessential in the prosecution of research, and many an ardent aspirant may be glad to know that, having really good object-glasses, he may with a very simple instrument confidently approach almost any branch of microscopical inquiry.

Having described the usual appurtenances of a microscope, and the mode of using them, the author gives the following list of chemical re-agents useful in microscopical inquiries, and of preservative fluids, which we have thought it might be useful to extract:—

"1. *Alcohol*, principally for the removal of air from sections of wood and other preparations; also as a solvent for certain colouring matters.

"2. *Æther*, chiefly as a solvent for resins, fatty and other essential oils, &c.; also useful for the removal of air.

"3. *Solution of Caustic Potass*, as a solvent for fatty matters; also of use occasionally, in consequence of its action upon the rest of the cell contents and thickening layers. This solution acts best upon being heated.

"4. *Solution of Iodine* (iodine 1 grain, iodide of potassium 3 grains, distilled water 1 ounce), for the coloration of the cell membrane and of the cell contents.

"5. *Concentrated Sulphuric Acid*, employed principally in the examination of pollen and spores.

"6. *Diluted Sulphuric Acid* (three parts acid, one part water), for the coloration of cells previously immersed in the iodine solution. The preparation is first moistened with the iodine solution, which is afterwards removed with a hair pencil, and a drop of sulphuric acid added by means of a glass rod; the preparation is then immediately covered with a piece of glass. The action of the sulphuric acid and iodine, as well as that of the iodized chloride of zinc solution, is not always uniform throughout the whole surface of the preparation. The colour is more intense where the mixture is more concentrated; it frequently happens that many spots remain uncoloured. The colour changes after some time, the blue being frequently changed into red after twenty-four hours.

"7. *A solution of Chloride of Zinc, Iodine, and Iodide of Potassium.*—A drop of this compound solution, added to a preparation placed in a little water, produces the same colour as iodine and sulphuric acid. This solution, which was first proposed and employed by Professor Schulz of Rostock, is more convenient in its application than iodine and sulphuric acid, and performs nearly the same services, whilst it does not, like the sulphuric acid, destroy the tissues to which it is applied. The precise composition is as follows:—

"Zinc is to be dissolved in hydrochloric acid, and the solution, in contact with metallic zinc, is to be diluted to a syrupy consistence, and the solution must then be saturated with iodide of potassium. Iodine is then to be added, and the solution, if necessary, diluted with water.

"8. *Nitric Acid*, or, what is better, chlorate of potass and nitric acid, as an agent to effect the isolation of cells. The mode of employing this means, also discovered by Professor Schulz, is as follows:—The object—a thin section of wood, for instance—is introduced, with an equal bulk of chlorate of potass, into a long and moderately wide tube, and as much nitric acid added as will at least cover the whole. The tube is then warmed over a spirit-lamp; a copious evolution of gas takes place, upon which the tube is removed from the flame, and the action of the oxydizing agent allowed to continue for two or three minutes. The contents of the tube are then poured into a watch-glass with water, from which the slightly cohering particles are collected and placed in a tube, and again boiled in alcohol as long as any colour is communicated. They are again boiled in a little water. The cells may now be isolated under the simple microscope by means of needles. The boiling with nitric acid and chlorate of potass should never be carried on in the same room with the microscope, the glasses of which may suffer injury from the vapours. Thin sections of vegetable tissue are warmed for half or a whole minute in a watch-glass; boiling is here unnecessary. The section is taken out, and treated with water in a watch-glass.

"9. *Oil of Lemons*, or any other essential oil, for the investigation of pollen and spores.

"10. A moderately strong solution of *Muriate of Lime* (one part dry muriate of lime, and three parts distilled water), for the preservation of microscopical preparations. This is applicable to most things, even for the most delicate preparations, excepting starch. If it is desired to keep a preparation, which is not to be retained permanently, for some days, a small drop of this solution may be placed upon it, and the whole placed under a glass cover to keep it from dust.

"11. *Glycerine*, also for the preservation of microscopical preparations. It is well adapted for the preparation of cells containing starch, which remains unchanged by it. In starch grains, exhibiting a laminated structure—as, for instance, in potato starch—the lamination is usually not apparent for the first few hours, but after about twenty-four hours it becomes more evident than before.

"12. *Copal Varnish* and *Canada Balsam*, also used for the preservation of microscopic objects. Both substances can only be employed in the case of a few thin sections of wood, especially of fossil woods; both render the object more transparent than the solution of muriate of lime.

"13. Lastly may also be enumerated a pretty strong solution of *Carbonate of Soda* and also *Acetic Acid,* which latter, however, is more especially useful in the investigation of animal tissues."

To the above may be added a test for protein compounds, which is described by the author in his larger and more recent work, 'Die Pflanzenzelle.' This test is composed of sugar and sulphuric acid, and is thus employed:—A very thin section or portion of the tissue to be examined is placed in a drop of simple syrup. This is then removed by means of a hair pencil, and a drop of sulphuric acid (three parts acid, one part water) added; the red colour usually does not appear till after the lapse of about ten minutes.

The third chapter contains general rules for the use of the microscope, and for the proper disposition and preparation of objects; from which, however, though all useful and concisely expressed, there is little of novel nature to extract. Dr. Schacht is of opinion, in which we cannot from experience but agree with him, that whoever has regard for his eyes will never employ the microscope for prolonged investigation by artificial light. In his directions for making thin sections of tissues, he recommends that, in the case of objects whose consistence differs in different parts, the section should be carried from the harder into the softer portion. He also in some cases recommends a procedure which is doubtless familiar to most of our readers, viz.: in the making of a thin section of a very minute yielding substance, to enclose it between two pieces of cork, and to slice the whole together. It is also useful sometimes to saturate the object with mucilage, which is to be allowed to dry slowly; in this way very delicate tissues may be sliced or otherwise divided without injury, and with great facility.

The fourth, fifth, and sixth chapters enter more specially upon the histology of vegetable tissues, and the modes in particular cases of pursuing its investigation. They contain matter of great utility, but do not admit of condensation. In all observations, Dr. Schacht strongly recommends the making of drawings of everything worth note observed. He strongly deprecates the making of mere diagrammatic figures, which only convey the momentary impression made upon the observer; in all cases an accurate drawing of the object, conveying "the truth, the whole truth, and nothing but the truth," should, if possible, be made: and in all cases where it can be employed, he strongly recommends, and himself always uses, the camera lucida.

The seventh chapter is devoted to the subject of making drawings from the microscope, and contains many sensible, useful, and minute directions, especially with respect to colouring.

The work concludes with a chapter upon the preservation of microscopic objects, but in which we do not notice anything sufficiently novel to warrant extraction, except one proceeding, which, as we have had an opportunity of seeing, is well worth following, and may perhaps be novel to some. It is the mode of preserving preparations of vegetable tissues in a solution of muriate of lime, and which, from its simplicity, efficacy, and permanence, appears to have much to recommend it. It is as follows:—

"A slip of glass of convenient size being perfectly cleaned, strips of paper are gummed across it, dividing it into as many compartments as may be desired. The strips at each end are rather wider than those between the divisions. These strips of paper serve not only for the subsequent joining of the two glass slips together, but also to prevent the pressure upon the preparations. The paper, therefore, of which the divisions are formed, should not be thinner than the objects, nor, on the other hand, should it be much thicker, as in that case the preparations would lie too loose.

"When these strips of paper are dry, and the glass again carefully cleaned, a drop of the muriate of lime solution is be placed in the centre of each compartment by means of a thin glass rod. It is advisable first to breathe upon the glass, as the drop of solution then adheres more readily to the surface. The objects to be set up require to be most carefully prepared. Preparations of recent soft objects are rarely treated with alcohol, whilst, on the other hand, sections of wood must always first be immersed in alcohol to remove resinous matters and air; but they must not be transferred immediately from the spirit to the muriate of lime solution—they must first be placed in a watch-glass in water, in order to remove the alcohol. From the watch-glass they may be carefully taken by means of a hair pencil, and conveyed to the drop of saline solution destined for their reception. It is often in this proceeding requisite to place the watch-glass upon a dark ground, in order to render the minute objects visible. When all the preparations are duly placed on the glass slip, it is brought under the simple microscope, and the objects properly laid out by means of needles or otherwise, and at the same time foreign particles of dust, &c., removed.

"In the conveying of the preparations, with the hair pencil, from the water to the muriate of lime solution, a dilution of the latter is unavoidable. It is, therefore, very necessary to remove, by means of a larger, perfectly clean pencil, the greater part of the solution in which the preparation is lying, which with a little care may readily be done without disturbance of the object. The fluid thus removed must then be replaced by an equal quantity of fresh solution. The size of the drop must be regulated according to the thickness of the paper employed to form the divisions. The drops of fluid and the contained preparations being thus arranged, each in the centre of its own division, and the latter properly laid out so as to exhibit clearly what they are intended to show, a little mucilage is smeared over each of the strips of paper, and the covering glass carefully placed upon the other, and pressed upon the divisions so as to cause it to adhere to them. The ends of the slips are then covered with paper, upon which are written remarks upon the preparations, with a date, &c.

"The chief difficulty in the setting up of preparations in this way consists in arranging the due quantity of the muriate of lime solution. If this be too small, the preparation will be uncovered by it on one side; and if too great, the fluid comes in contact with the paper forming the strips, and, being absorbed by it, the preparation is equally left dry. In neither case, however, is it injured, as it is always saturated with the solution; but as in this state it is useless for the purpose of examination, it is frequently necessary to repeat the entire process. This is done by immersing the slide in water, and, when the slips of glass are separated, the preparations are to be again laid out in the way above described. When the process, however, has been duly effected, no further care of the preparation is requisite, except the always keeping it lying flat."

Glycerine may be employed in the same way; but the author appears to think that in the employment of this fluid it is necessary to close the edges of the space between the glasses with some air-tight cement.

THE MICROSCOPIST; or a Complete Manual on the Use of the Microscope. By JOSEPH H. WYTHES, M.D. Philadelphia. Lindsay and Blakiston.

THE history of the microscope, like that of many other useful human inventions, has been a chequered one. When first brought into use at the end of the seventeenth and the beginning of the eighteenth century extravagant expectations were formed of its value—expectations which were almost justified by the discoveries of Swammerdam, Hooke, Leeuwenhoek, and others. It failed, however, to realise these brilliant hopes, and we find the science of observation progressing rapidly from the middle of the eighteenth to the beginning of the nineteenth century without the aid of the microscope. Linnæus, the great presiding genius of natural history at this period, had put his ban upon this instrument, and publicly announced his opinion of its worthlessness in the pursuits of the naturalist. It, however, maintained its position in the toy-shops, and though disregarded by the man of science, it was a successful means of exciting the wonder of the ignorant in the hands of the mountebank. Even after the improvements of the microscope in the present century by Brewster, Lister, and others, which made it once more an instrument of observation, and the discoveries of Brown, Ehrenberg, Müller, and their contemporaries, it has not lost its hold on the public mind as a source of wonder, and a toy with which to pass away hours that would otherwise be found wearisome enough. We would not on this account propose a classification of those who possess microscopes into those who use them as toys and those who use them as philosophical instruments. It is certain, however, that the two classes exist and they probably run one into the other at many points, and we only allude to the subject here by way of warning to those who use or write upon the microscope to avoid the tendency to regard it as a mere instrument of amusement. The simplest combination of lenses that can be bought at a toy-shop may be made a means of instruction to the children for whom they are made. The microscope is, in fact, but an instrument or tool, and in this respect is like all others by the use of which certain ends can be attained and objects effected which could not be without its employment. As cutting with a sharp instrument is better than tearing with the nails, so vision with the microscope is better than with the naked eye. Its use is, therefore, as extensive as that of the organ which it assists, and it cannot be regarded as the property of one branch of science more than another. It is true that in revealing the intricate structure of organized beings it has been more extensively employed by the physiologist and naturalist than by other scientific inquirers, but it cannot be claimed exclusively for histology or any other branch of science. But whatever may be the department of inquiry in which this important instrument is employed, the general principle of its construction and use are the same, hence the demand for books treating of its structure, and explaining the manner of its use and application. Of the various treatises that have been devoted to this subject in the European languages, we have no hesitation in pronouncing that by Professor Quekett as far the best, and we hope in our next number to have an opportunity of noticing the second edition of this excellent work. Still we have always regarded Mr. Quekett's work as too minute and extended, as well as too expensive, to serve the purposes of those who only want an explanation of the instrument and a few plain directions for its use. The little work published in America by Dr. Wythes in size and price is evidently more adapted for general use. Its plan and contents are so evidently founded upon the work of Mr. Quekett that we wonder the author did not at once acknowledge how largely he is indebted to that gentleman's labours. It is one of the grievances that literary men have to complain of in this country, that their works are reprinted in America without their obtaining any profit from the wide sale they meet with in that country, and the least they have to expect is, when their works are reprinted or extensively drawn upon, that the debt be acknowledged.

As an instance of how much Dr. Wythes is indebted to the English professor, we would quote the chapter on Test-objects, which is scarcely more than an abstract of the chapter on the same subject in Mr. Quekett's book, and in which no pains have been taken by an alteration of expression to conceal the source of the information. The plates illustrative of this subject are also copied from Mr. Quekett's work, as well as many others.

Although Dr. Wythes' work is intended for all who use the microscope, it is very evident that his own acquaintance with this instrument has been almost exclusively confined to animal tissues. Thus, speaking of the "circulation in plants termed *cyclosis*," he says, "It can be observed in all plants in which the circulating fluid contains particles of a different refractive power or intensity, and the cellules are of sufficient size and transparency. Hence all lactescent plants, or those having a milky juice, with the other conditions, exhibit this phenomenon." He has here confounded the general movement of the sap witnessed in lactescent plants with cyclosis. Again, in a chapter somewhat singularly called the "cell-doctrine of physiology," in speaking of the development of cells within other cells, he says, "each granule of the nucleus has the power of developing a cell;" and without any allusion to this as a controverted opinion, or to any other form of cell-development, he leaves the subject. It would perhaps be better in works of this kind that all physiological views and general principles arising out of the investigation of particular structures should be omitted. All that is required is a reference to the various classes of objects in which the microscope is found of advantage, and directions as to the best methods of examining such objects. In the present instance we find no directions given as to the best way of exhibiting the cytoblast or the objects best fitted for showing it. Another omission in this book of more importance is the entire absence of any allusion to the use of re-agents in the examination of animal and vegetable tissues. The aid of chemistry has become so important in distinguishing certain tissues under the microscope, that too much stress can hardly be laid upon it in any directions for its use.

The work is illustrated with a great number of wood-cuts; some of those of microscopic objects are very coarsely done. This is a pity, as too great pains cannot be taken in making evident in drawing those distinctions which are evident with the microscope. The wood-cuts, for instance, of the caudate cells, in figs. 36, 40, 41, and 42, are not sufficiently different to lead a young microscopist to the belief that by their means a distinction may be made out between an innocuous and a malignant tumour. We are sorry to have to find so much fault with this book, but it contains the elements of a useful volume, and, if we may judge from its sale in this country, the present edition is likely soon to be sold off, and to afford Dr. Wythes an opportunity of correcting its errors, acknowledging his debts, and extending his work in those directions in which it is most deficient.

NOTES AND CORRESPONDENCE.

New Methods of Constructing the thin Glass and built Cells for Preserving Objects in Fluid.—In consequence of the difficulty of making the thin glass cells now in use, they are not so frequently employed by microscopists as they would be if their manufacture were more simple, and they could be obtained at less cost. One method of making these thin cells consists in grinding down a thick section of glass tube, or thick glass bottle, until the requisite tenuity has been obtained. This process is obviously quite as laborious as that of drilling through several squares of the thin glass cemented together by marine glue, and afterwards separating them for mounting on the glass slide. By either of these processes it is obviously difficult to obtain cells varying much in size, the usual dimensions of the cell being not more than half an inch in diameter; and it is almost impossible to make large shallow glass cells by either of the above-mentioned methods.

Method of making the thin Glass Cell.—Some time ago a very simple method of perforating the thin glass occurred to me, which has been found to answer exceedingly well, and it has this great advantage, that the microscopist can make cells for himself of almost any dimensions required.

The principle of the process depends upon the fact that a crack will not extend across any part of a piece of thin glass which is fixed by marine glue to any firm surface to which it is capable of adhering. The edges of the thin glass may be broken in all directions, but the crack will extend only up to the marine glue, and no farther. If a piece of thin glass be fixed by marine glue to one of the thick sections of tube used for making cells in which injections are mounted, and allowed to cool, a hole may be made in the centre with a file, which may then be carried round the edges, and a thin glass cell exactly the size of the thick one is produced. It is removed by heating the glass, and may then be transferred to a slide and fixed at once, or the glue adhering to it can easily be removed by soaking it for a short time in potash. The surfaces may be roughened, or the cell may be ground thinner by rubbing it on a flat surface with emery-powder in the usual way.

All that is requisite, then, to make thin glass cells of any required form and dimensions, is to obtain a perfectly flat, thick ring, to which the glass may be cemented, and in a few minutes several thin cells of large size may be made, and at very trifling cost.

It may not be out of place here to describe a very simple method of cutting the circular glass covers for thin glass cells. For this purpose several beautiful forms of apparatus have been devised; amongst others may be mentioned that of Mr. Darker, by aid of which circles of any diameter may easily be cut. A very simple form of apparatus may be made by soldering on each side of several common brass curtain-rings a straight piece of wire, as in the figure, by means of which the ring can be held firmly by two fingers against the thin glass lying on a perfectly flat surface. The writing diamond is then carried round the inside of the ring, and the circular piece of glass is readily obtained. The rings may be purchased of any size, and by a little bending they may be formed into a very good oval for cutting thin glass of this form.

Method of making the built Glass Cell.—The usual plan of constructing the deep glass cells, by joining together several slips of thick plate glass, the edges of which have been ground perfectly flat, and cementing them at the angles with marine glue, is a process of considerable labour. For some time past I have been endeavouring to devise a method by which these cells could be more readily made, as their advantage over bottles for mounting many preparations is obviously great. The process about to be detailed requires some practice, but, when this is acquired, cells may be made much more rapidly than by the old method, and have the advantage of possessing fewer joins.

A slip of plate glass, of the required depth, of about the eighth of an inch in thickness, and of sufficient length to make all four sides of the cell, is taken. The length of each side is to be accurately marked upon it with a spot of ink, and in these situations the glass is to be carefully and very gradually raised to a red heat in the blow-pipe flame, and then bent so as to form a good angle; care being taken not to twist the glass in the slightest degree. The other angles are formed in the same manner, each being cooled as gradually as it was heated. The ends are to be afterwards cemented together by heating in the blow-pipe. If the last side when bent round should be found to be too long, a small portion can be cut off by aid of the diamond, and, with a little care in heating the ends and pressing the glass together when in a softened state by a small piece of wire, an excellent juncture may be made; or, if preferred, the join may be effected in the centre of one of the sides. In this way cells may be made of half an inch in depth, or rather more, and of any required size. The great difficulty in constructing cells in this way arises from the glass cracking in the process of heating or cooling, and from the tendency of the sides to twist when the glass is softened in the position of the angles. The latter difficulty is soon overcome by practice; the former would be avoided if, instead of the ordinary plate glass, flattened and well-annealed flint glass were employed; and I believe that, with this modification, the construction of cells would be much simplified, and they might be made at a cost far less than that for which built glass cells can now be obtained. When the angles are formed and the glass joined, the surfaces are ground flat in the usual way; and if care be taken to prevent twisting, this part of the process is soon executed. After grinding they are fixed to a flat plate-glass slab with marine glue. I have succeeded in making several cells in this manner which have now had preparations in them for upwards of two years.—LIONEL S. BEALE, M.B.—27, *Carey Street*, *Aug.* 1852.

STRUCTURE OF THE EPIDERMIS OF THE PETAL OF THE GERANIUM.—The petal of the Geranium is one of the most common and beautiful objects in microscopic cabinets. The usual way of preparing it is by immersing the leaf in sulphuric ether for a few seconds, allowing the fluid to evaporate, and then putting it up dry. Another is by simply drying the petal, immersing for an hour or two in spirits of turpentine, and then putting it up in new Canada balsam.

By neither of these plans is the true structure shown; we can recognise the mamillary process of each cell, but not the few hairs which surround their margin.

The only way in which I have succeeded in preserving these is the following:—I first peel off the epidermis from the petal, which may readily be done by making an incision through it at the proximal end of the leaf, and then tearing it forwards by the forceps. This is then arranged on a slip of glass, and allowed to dry; when dry, it adheres to the glass; place on it a little Canada balsam diluted with turpentine, and boil it for an instant over a spirit-lamp; this blisters it, but does not remove the colour. Cover then with a thin slip to preserve it. On examination many cells will be found showing the mammilla very distinctly and the score of hairs surrounding its base, each being slightly curved and pointing towards the apex of the mammilla. It is these hairs and the mammilla which give the velvetty appearance to the petal.—THOMAS INMAN, M.D. *Liverpool.*

ON THE FORMATION OF DOTTED TISSUE.—Bothrenchyma forms a very popular microscopic object. It is interesting to examine the way in which it may be formed. It may be produced, as in rhubarb, by the filling up of interspaces between fibres until a small pit only remains: or, as in the *Alnus serratula*, by a number of lines, arranged at first like those of a ladder, then united by transverse ones forming a grating, the angles being filled up and rounded last: or, as in the *Populus tremuloides*, by an uniform deposit over the whole membrane. It is generally known that bothrenchyma does not exist in coniferous wood, but in some varieties a dotted tissue may be distinctly made out, situated in the medullary rays. The wood in which I have found it is that of which eau de Cologne boxes are made. Its rudiments are to be found in common deal. The formation is readily accounted for. Wherever the two sets of fibres or cells cross each other, their angles are filled up, and they form apparently a grating of round holes instead of square. They could never be mistaken for genuine bothrenchyma.

I have heard many suggestions as to the use or intention of these little pits; passing by the obvious one of their promoting the easy transmission of fluid, the following seems the most striking. They are intended to unite the utmost possible strength with the utmost possible lightness—*e. g.*, if an engineer wanted to cast a pillar which should combine these two qualities, he would mould it on a plan precisely similar to a dotted duct.—IBID.

OPTICAL PROPERTIES IN A SALT OF QUININE.—Dr. Herapath, of Bristol, has recently described a salt of quinine, which has remarkable polarizing properties. The salt was first accidentally observed by Mr. Phelps, a pupil of Dr. Herapath's, in a bottle which contained a solution of disulphate of quinine. The salt is best formed by dissolving disulphate of quinine in concentrated acetic acid, then warming the solution, and dropping into it carefully, and by small quantities at a time, a spirituous solution of iodine. On placing this mixture aside for some hours, brilliant plates of the new salt will be formed. The crystals of this salt, when examined by reflected light, have a brilliant emerald green colour, with almost a metallic lustre; they appear like portions of the elytra of cantharides, and are also very similar to murexide in appearance. When examined by transmitted light they scarcely possess any colour—there is only a slightly olive-green tinge; but if two crystals, crossing at right angles, be examined, the spot where they intersect appears as black as midnight, even if the crystals are not 1-500th of an inch in thickness. If the light be in the slightest degree polarized—as by reflection from a cloud, or by the blue sky, or from the glass surface of the mirror of the microscope placed at the polarising angle 56° 45′—these little prisms immediately assume complementary colours: one appears green, and the other pink, and the part at which they cross is a chocolate or deep chestnut brown, instead of black. As the result of a series of very elaborate experiments, Dr. Herapath finds that this salt possesses the properties of tourmaline in a very exalted degree, as well as of a plate of selenite, so that it combines the properties of polarizing a ray and also of depolarizing it. Dr. Herapath states, in his last communication to the 'Pharmaceutical Journal' on this subject, that he has succeeded in making an artificial tourmaline large enough to surmount the eye-piece of the microscope, so that all experiments with those crystals upon polarized light may be made without the tourmaline or Nicholls prism. He says that the brilliancy of the colours is much more intense with the artificial crystals than when employing the natural tourmaline. As an analyser above the eye-piece, it offers some advantages over the Nicholls prism in the same position, as it gives a perfectly uniform tint of colour over a much more extensive field than can be had with the prism.

DESQUAMATION OF PULMONARY AIR-CELLS.—Attention has recently been called to the value of the microscope in diseases of the kidney. It has frequently been appealed to in diseases of the lungs, but with less success. My intention is to show that in some rare cases some similarity may be found microscopically between the one and the other.

Dr. G. Johnson has pointed out how constantly one form of inflammation of the kidney shows itself by epithelial desquamation, and how generally the casts of the urinary tubes so produced may be found in the urine.

I have on one occasion discovered the traces of a similar process in the lungs. A friend forwarded me some expectoration from a patient, with a request that I would examine it, and give an opinion, if I could, whether the case was one of phthisis or bronchitis, a question her attendants were unable to solve. As the examination was somewhat instructive, I will give its detail. The first specimen I examined contained abundance of pus and mucous granules, a number of oil globules, and some scattered particles of starch. There was also a fragment or two of fibrous tissue, which might or might not be a portion of broken-down lung. I soon succeeded in obtaining larger specimens of this, and found it was a cell-structure too regular for any in the animal world. By charring, it gave a vegetable smell, and reminded me of burnt bread. I then procured some bran, and found that it resembled it closely. The first diagnosis was then, that the patient had been eating bread and butter. I next took some of the sputa and agitated them with water for a considerable time, boiling at last to dissolve the mucus completely. After a time a white sediment appeared at the bottom of the vessel, consisting of very minute granular particles. These, when examined under the microscope, were found to be accumulations of epithelial cells, arranged in a hollow globular form, and measuring about 1-500th of an inch in diameter. Most of them were single, and had a small entrance tunnel sometimes opening into a fragment of a larger tube. They resembled very closely a roughly-cast bullet before it has been trimmed. Here and there others were found in small masses, like a diminutive bunch of grapes. The rest of the deposit was made up of amorphous granular membrane, and seemed as if it had come from a large cavity. I considered that the evidence was scarcely sufficient to enable any decided opinion to be given; for it was not absolutely certain (however probable it was) that these casts of cells came from the lungs, and, if they did, whether they indicated simple inflammation or tubercular disease. The woman suffered much from relaxation of the soft palate, and the cells might be from its mucous glands.

The patient died shortly after, and no examination was allowed.

The results of this case induced me to examine others of confirmed phthisis, but in one instance only have I been able to find a similar appearance. The most common phenomenon is that of a brownish amorphous membrane, of variable size and shape, studded with oil globules and small nuclei, and which seems to be the secretion from a diseased surface, and analogous in a small degree with the amorphous casts found in chronic desquamative nephritis. As these membraniform bodies evidently come from large cavities, and have not been found in those specimens of simple bronchitis that I have examined, their occurrence in the sputa may probably form a diagnostic sign between it and phthisis. My observations have not as yet been sufficiently extended to enable me to declare positively that they are diagnostic. I would only add, as a sort of apology for my first diagnosis, the following anecdote :—A microscopic friend, while examining the sputa of a phthisical patient, detected in it a number of muscular fibres exhibiting the striæ more beautifully than in any preparation he had ever seen. After a long consideration of the case and consultation with another, he came to the conclusion that there was ulceration of some parts of the larynx with loss of muscular substance. It was not for some time after that he ascertained that the sputa were taken after dinner, that the patient had had meat, and that the fibres were due to a slaughtered ox, and not to a human larynx.—T INMAN, M.D. *Liverpool.*

THE MISCROSCOPE AS A TEST OF THE PURITY OF DRINKING WATERS.—In the examination of waters supplied by nature for dietetical and economical purposes, a chemical examination of their contents has been usually deemed sufficient in order to ascertain their qualities. It is, however, evident that, however accurately chemistry might be able to pronounce on the quantity of the organic contents of waters, the qualities of these matters can only be ascertained by means of the Microscope. We are indebted to Dr. Hassall for first taking up this subject; and during the last Session of Parliament Dr. Lankester and Dr. Redfern were examined before the Committee of the House of Commons, on the water supply of the Metropolis, with reference to the Microscopic contents of the Thames and other waters. A report has been drawn up by these gentlemen at the request of the London (Watford) Spring Water Company, in which they give the results of their examination of waters supplied from the Thames, the New River, the Surrey Sand Springs, the river Dee, and water from wells at Watford. The mode of proceeding was, to take half a gallon of the water to be examined, and, after allowing it to stand for a few hours, to decant the clear liquid from above till about half an ounce remained. A drop of this was taken up by a pipette and examined under the Microscope. It would appear from these reports that, in proportion to the absence of inorganic and organic matters in a state of decomposition, is the water free from microscopic plants and animals. Great differences in these respects are presented by the water examined. Thus, in the river Dee and the Watford water, scarcely a living organism was found, whilst in the Thames and New River waters above seventy species have been identified by the reporters.

PROCEEDINGS OF SOCIETIES.

Microscopical Society of London. Session 1852.

January 28.—Dr. Arthur Farre in the Chair. On the structure of the Raphides of *Cactus enneagonus*, by Professor Quekett.

February 18.—Anniversary Meeting.

March 17.—George Jackson, Esq., in the Chair. Hints on the subject of collecting Objects for Microscopical Examination, by George Shadbolt, Esq.

April 28.—George Jackson, Esq., in the Chair. On a Cyst, containing a large crystal of oxalate of lime, found upon the olfactory nerve of a horse, by James B. Simonds, Esq.

May 26.—George Jackson, Esq., in the Chair. On the development of *Tubularia indivisa*, by J. B. Mummery, Esq.

On the structure and development of Volvox globator, by George Bush, Esq., F.R.S.

June 23.—George Jackson, Esq., in the Chair. On the Anatomy of Volvox globator, by Professor W. C. Williamson.

British Association for the Advancement of Science.

Belfast Meeting, *September* 1852.—In the Mathematical Section Sir David Brewster gave an account of a Rock Crystal Lens, which had been found in the treasure-house in the ruins of Nineveh. The lens was not entirely circular in its aperture, being 1 6-10ths of an inch in its longer diameter and 1 4-10ths in its shorter. Its general form was that of a plano-concave lens, the plane side having been formed of one of the original faces of the six-sided crystal of quartz. The convex face of the lens was unequally thick, but its extreme thickness was 2-10ths of an inch, its focal length being 4½ inches. It had twelve remains of cavities, which had originally contained liquids or condensed gases; but ten of these had been opened, probably in the rough handling which it received in the act of being ground.

Professor Stokes read a paper on the Optical Properties of the Salt of Quinine, discovered by Dr. Herapath (p. 59). He explained the remarkable properties possessed by this salt according to the undulatory theory. The reflecting properties of these crystals, he stated, might be embraced in one by regarding the medium as not only doubly refracting and doubly absorbing, but *doubly metallic*. The principal object of the paper was to point out the intimate connexion which exists between the coloured reflection, the double absorption, and the metallic properties of the medium.

In the Natural History Section Professor Allman read a paper on the signification of the ovigerous vesicles in the Hydroid polyps. He stated that the structure of these vesicles was the same as that of the naked-eyed medusæ. From repeated observations, he had come to the conclusion that the ordinary polypoid structure is not sufficient for the production of ova, and that for these bodies a medusoid structure is always necessary, whether it be obvious as in the free gemmæ, or disguised as in the fixed ovisacs.

The Rev. T. Hincks read a paper, in which he pointed out certain peculiarities in the structure of some of the marine Bryozoa, which led him to the conclusion that there existed in these animals a difference of sex.

Mr. Wyville Thomson read a paper on the specific characters of some of the Sertularian zoophytes. He endeavoured to point out the fallacy of using the ovigerous vesicles as means of specific distinction in this class of animals, and observed that forms of the same species had been separated by relying on the characters afforded by these organs.

Professor Allman made a communication on the presence of a form of fermentation-fungus in the fluid of the warm water flax-steeps. After the flax has been in the water a few hours, the water, on being submitted to the microscope, presented numerous minute granules, which moved about by the aid of a moving cilium. Sometimes two of these bodies were attached at each end of the cilium. They ultimately became converted into cells, which produced smaller cells upon their surface, eventually assuming the form of a moniliform alga.

Professor Allman likewise described a minute alga, which had coloured green large masses of water. It was in the form of little conglomerated gelatinous masses, consisting of numerous fronds. The fronds were nearly spherical, and consisted of a central mass of transparent gelatinous matter surrounded by an outer coating of minute cells of a green colour. The external crust bursts, and allows the gelatinous nucleus to escape, which then separates into two distinct fronds by a process of contraction.

A paper was read from Professor Wharton Jones on the forces by which the circulation of the blood is carried on. In this paper reference was made to a discovery announced by the author, in a paper read before the Royal Society on the 5th of February, 1852. This discovery consists in the fact of a rhythmical contraction existing in the walls of the veins of the bat's wing. These veins are supplied with valves which prevent the regurgitation of the blood; and the author suggests that this contractility of the veins is a provision for securing the return of the blood to the right side of the heart. The author could not discover this contractility in the ear of the bat, nor in the mesentery of a mouse.

DESCRIPTION OF PLATE I.

On Actinophrys Sol, *by Professor Kölliker.*

Fig. 1.—Apparent transverse section of *Actinophrys Sol*, drawn so that the parts visible in indistinct outline are not indicated. The structure exhibited in this figure is afforded by *Actinophrys* in any plane passing through the centre. *a*, cortex: *b*, nucleus of the animalcule; *c*, homogeneous basal substance; in the nucleus with numerous granules; *d*, hollow spaces, '*Vacuoles*,' filled with a clear fluid; *e*, tentacular filaments.

Fig. 2.—The same, less highly magnified, at the moment of feeding. *a*—*e* as above; *f*, an Infusorium, which has just entered the substance of the body, whilst the surrounding filaments enclose it on all sides; *g*, a spore of an Alga already nearly engulphed in the cortical substance; the depression in which it is contained, however, is still open to the exterior, the filaments are again nearly erect; *h*, a spore of *Vaucheria*, lying in a hollow space of the nuclear substance.

Fig. 3.—A somewhat more highly magnified *Actinophrys*, with very short just-sprouting tentacular filaments. *a*—*e*, as in fig. 1; *f*, a *Vaucheria* spore, wholly imbedded in the cortical substance, the opening through which it entered entirely closed, although its situation is indicated by a slight depression; *g*, another spore, already entering the nuclear substance; *h*, an Infusorium lying in a special cavity; *i*, a spore in the nuclear substance; *k*, half-digested morsels; *l*, a swallowed *Lynceus*; *m*, excrementitious matter in the form of a spherical, clear drop, with granules, beginning its exit from the cortical substance. A portion of it is already protruded from an opening, the margin of which is fringed.

Fig. 4.—A smaller portion of the border of an *Actinophrys*, magnified 450 diameters. *a*, *c*, *d*, *e*, as in fig. 1; *f*, sprouting, conical, tentacular filaments; *g*, one a little longer; *h*, enlargement upon a developed but not extended filament.

Fig. 5.—A portion of the nuclear substance, magnified to the same extent. *c*, *d*, *e*, as before; *f*, nucleus in one of the hollow spaces; *g*, a cell? from another hollow space, isolated.

Fig. 6.—A true anastomosis of three striped muscular fasciculi from the auricle of the frog. *a*, sarcolemma; *b*, fibrillæ, with transverse stripes.

On the Contractile Tissue of the Iris, by Joseph Lister, Esq.

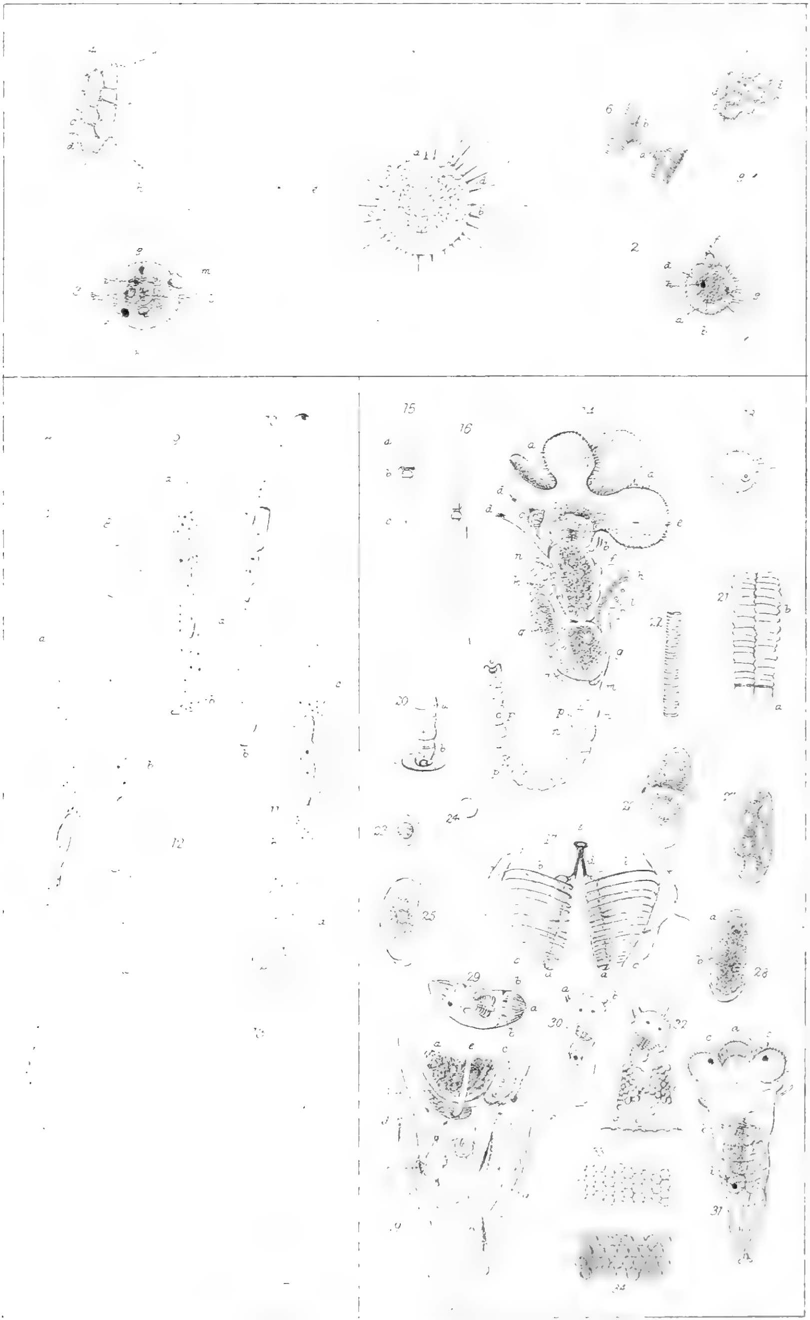
Figs. 7, 8, 9, 10, 11. Muscular fibre-cells of the human iris.

Fig. 12.—Nucleus from the sphincter pupillæ of a horse.

13.—Muscular fibre-cells from the edge of the pupillary margin of the iris.

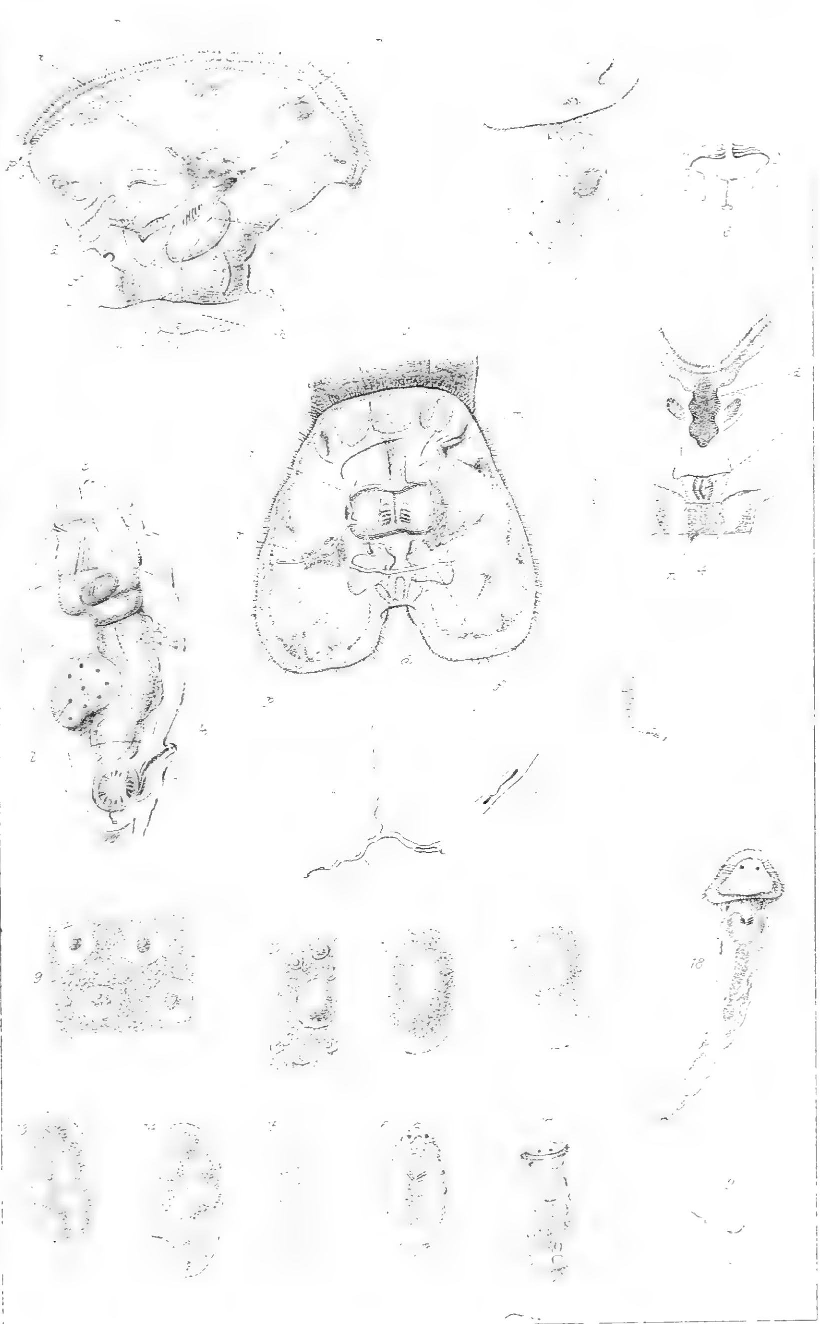
Anatomy of Melicerta ringens, *by Professor Williamson.*

Fig. 14.—Animal of *Melicerta ringens* removed from its case.
15.—One of the tentacles (Fig. 14 *d*) fully expanded.
16.—The same, with the setæ drawn inwards.
17.—Dental apparatus (Fig. 14 *e*) more fully magnified.
18.—One of the ciliated epithelial cells from the upper stomach.
19.—Lower part of the visceral cavity, and upper part of the caudal prolongation, more fully magnified.
20.—Extremity of the caudal prolongation expanded into a disc.
21.—Muscular fasciculi, invested with their sarcolemma in a state of corrugation.
22.—Ditto, with the sarcolemma stretched out.
23.—One of the nuclei of the ovary with its nucleolus.
24.—The nucleus, as removed from a fully-formed ovum. The nucleolus absorbed.
25, 26, 27, 28, 29. Ova in various states of development.
30. The animal of Fig. 29 just liberated from the ovum.
31.—The same animal in motion.
32. The young animal affixed to a leaf, and commencing the construction of its external case,
33.—Portion of the case at its lower extremity.
34.—The same at its upper extremity.



Tuffen West del.

Ford & West Imp. 54 Hatton Garden



T. Huxley del. Tuffen West sculp.

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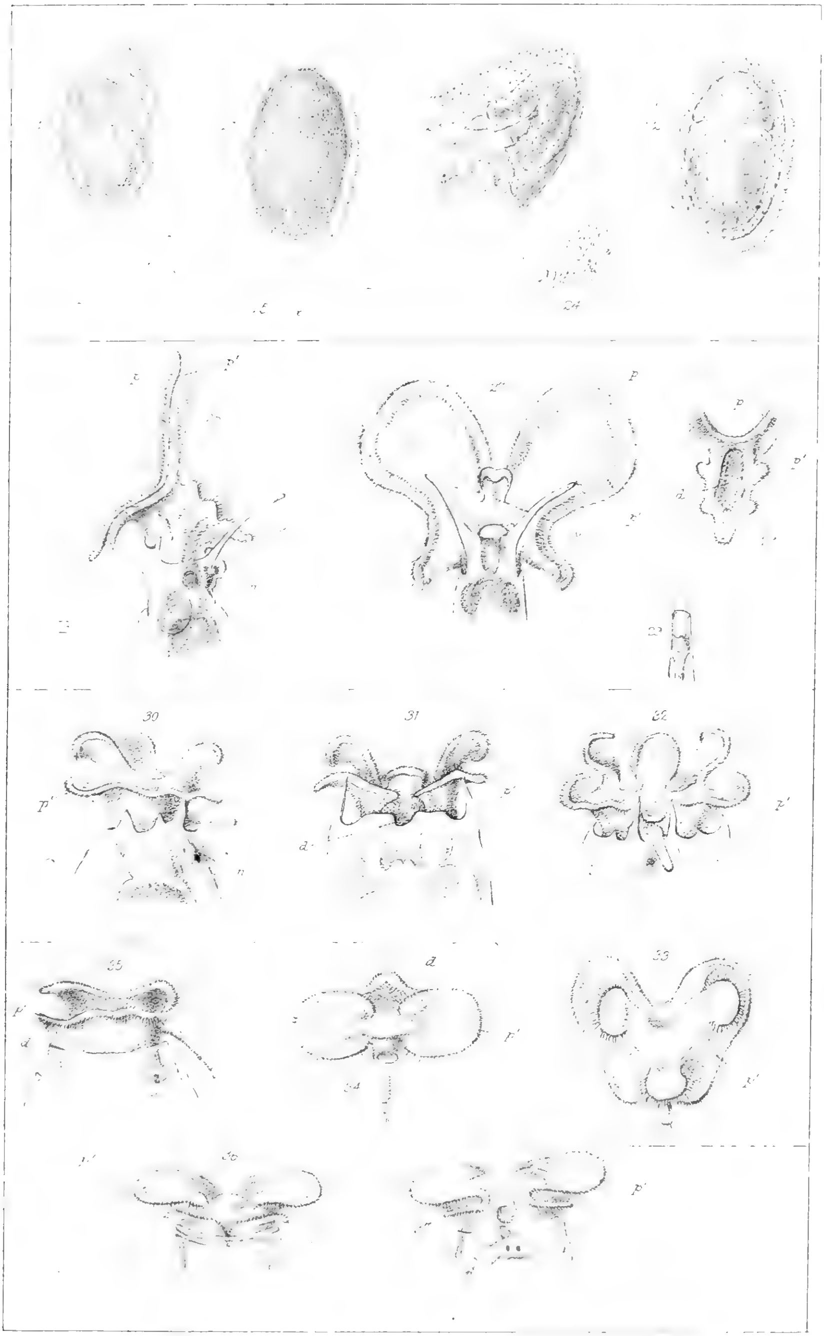
LACINULARIA



T. Huxley del. Tuffen West sculp.

Ford & West Imp. 54 Hatton Garden

A LACINULARIA B MELICERTA C BRACHIONUS

DESCRIPTION OF THE PLATES.

The letters throughout have the same signification:—*a*, trochal disc; *b*, body; *c*, tail of peduncle; *d*, mouth; *e*, pharynx; *f*, "yellow mass;" *g*, gizzard; *h*, "pancreatic sacs;" *i*, rectum; *k*, anus; *l*, ovary; *m*, water-vessels; *n*, ganglion; *o*, ciliated sac; *p*, upper circlet of cilia; *p′*, lower circlet of cilia; *r*, vacuolar thickenings.

PLATE I.—*Lacinularia socialis.*

Fig.
1. A single individual from the side.
2. Lateral view of the trochal disc.
3. Trochal disc from above.
4. Aperture of the mouth—ciliated sac and ganglion.
5. Animal retracted.
6. Armature of the gizzard, viewed laterally.
7. Termination of a water-vessel in the trochal disc.
8. Water-vessel much magnified, showing the long flickering cilium.
9. A portion of the ovary much magnified, showing the germinal vesicles with their spots scattered through its substance.

10, 11. Stages in the growth of the ovum.
12-18. Stages in the development of the embryo.
19. Spermatozoon?

PLATE II.

20. A portion of the ovary undergoing the change into an ephippial ovum.
21, 22. Ephippial ova, the latter having its contents divided into two portions.
23. Ephippial ovum burst.
24. Its contents.
25. Muscular fibre—relaxed, *a*; contracted, *b*.

Melicerta ringens.

26. Viewed laterally.
27. From the ganglionic side.
28. From the mouth side.
29. Extremity of the calcar, showing its apparent closure and the bundle of cilia.

Brachionus polyacanthus.

30. Viewed laterally.
31. From the mouth side.
32. From the ganglionic side.
33. From above.

Philodina, sp.?

34. Trochal disc from above.
35. ———— laterally.
36. From the mouth side.
37. From the ganglionic side.

PLATE III.

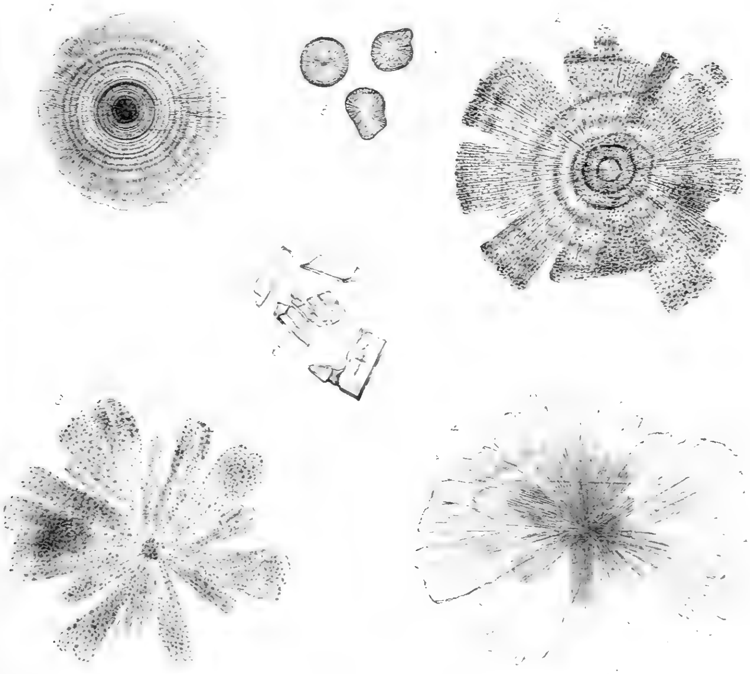
The Diagrams of Adult Rotifera, and of Larval Annelids and Echinoderms, illustrate Mr. Huxley's paper on *Lacinularia.*

Fig.

1. Raphides from *Cactus enneagonus,* showing a nucleus surrounded by concentric laminæ.
2. The same, with irregular laminæ.

3 & 4. The same, without concentric lamination.

5. Nuclei of raphides.
6. Separated crystals of compound raphides.



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ORIGINAL COMMUNICATIONS.

On the Anatomy of MELICERTA RINGENS. By Professor W. C. WILLIAMSON.

[Continued from page 8.]

The most interesting portion of the history of *Melicerta* is connected with the development of its ova, which process the transparency of its organs enables us to watch with facility. I have already described the position of the ovary and oviduct. The ovary is a hollow sac consisting of a very thin pellucid membrane. It is filled with a viscid granular protoplasm of a light grey colour, in which are distributed from twenty to thirty nuclei (23), each having a diameter of from 1-1200th to 1-1600th of an inch. Each nucleus contains a large nucleolus varying in diameter from 1-1600th to 1-3500th. In its normal state, the granular protoplasm is of an uniform grey colour, flowing freely out of the ovary when the latter is ruptured. The nuclei situated near the centre of the ovary appear to be successively selected for development. One of these nearest the surface attracts round it a small portion of the granular protoplasm, detaching it from the remaining contents of the organ, though still in close contact with them. The portion thus specially isolated gradually enlarges, assuming at the same time a darker hue, whilst, from its central position, it partially divides the upper from the lower half of the remaining ovarian protoplasm. At the same time the central nucleus sometimes undergoes some slight enlargement, and its nucleolus appears to become absorbed; the position of this nucleus in the centre of the ovum is now indicated by an ill-defined transparent spot; but on bursting the protoplasmic mass it is seen to be a small spherical cell (26) about 1-1000th of an inch in diameter, having very thin pellucid walls, and scarcely any visible cell-contents. When the ovum thus segmented from the ovarian protoplasm has attained its full size (14 *q*), it becomes invested by a thin shell, which is apparently a secretion from its own surface. This view of its origin is of course difficult to prove, but I have sought in vain for evidence that it could have been formed in any other way.

The ovum being now ready for expulsion, it is slowly forced down to the lower part of the ovary, the stomachs being drawn upwards and to one side in order to make way for it. Yielding to the pressure produced by the successive contractions of the body, the ovum sweeps round the inferior border of the lower stomach, and, passing through the dilated oviduct, enters the cloaca. The latter canal becomes entirely everted, as is the case when the excrements are discharged, and by a sudden contraction the ovum is expelled.

At this stage of its development the egg has an average length of 1-150th of an inch, and a diameter of 1-250th. Its yolk usually consists of a single segment (14 *q* and 25), there being a small space at each extremity of the egg which the yolk does not occupy. Very soon, the central nucleus becomes drawn out and subdivides into two, this division being followed by a corresponding segmentation of the yolk (26). The same process is repeated again and again (27), until at length the entire yolk is converted into a mass of minute cells (28). The first trace of further organization which presents itself appears in the form of a few freely moving ciliæ. These present themselves at two points, one at 28 *a*, which corresponds with the future head, and the other near the centre of the ovum (28 *b*), which is destined to become the cavity of the stomach: shortly after this appearance of ciliæ, traces of the central parts of the dental apparatus present themselves, this again being soon succeeded by the union of the entire mass of yolk-cells, and the formation from them of the various organs of the animal (29). The ciliæ now play very freely, especially at the head (29 *a*). The creature twists itself about in its shell; two red spots (29 *b*) appear near the head, which Ehrenberg regards as organs of vision, and along with them a very dark brown and somewhat larger spot is developed in the integument near the lower stomach. The young animal now bursts its shell, and, on first emerging, presents the appearance of fig. 30; the two hooks are formed (30 *a*) as well as rudiments of the two tentacles (30 *b*), and the whole of its internal organization, though but obscurely seen, is nevertheless that of the perfect animal, and not that of a larval state.

Almost immediately after its escape from the egg, the young Melicerta stretches itself out, and everting the anterior part of its body unfolds several small projecting mamillæ covered with large ciliæ, by means of which it floats freely away. Its present form is seen in fig. 31. The ciliated mamillæ (31 *a*) at this stage of growth are not unlike those seen in Notammata clavulata, but they soon enlarge and become developed into the flabelliform wheel-organs of the matured animal. The dental apparatus (31 *b*) is now fully developed; the alimentary canal and muscular fasciculi are all present, only the epithelial cells of the former have not as yet obtained their yellow granular contents, consequently the viscera exhibit the same hyaline aspect as the rest of the organism.

The two red specks (31 *c*) are imbedded in two of the mammillæ.

After swimming about for some time, like other free Rotifera, the animal undergoes further changes. The dark brown spot (31 *d*) is the first to disappear, and soon afterwards the two pink ones (31 *c*) cease to be visible. The animal attaches itself by the tail to some fixed support, and developes from the skin of the posterior portion of its body a thin hyaline cylinder, the dilated extremity of which is attached to the supporting object. This structure has been already noticed by Dr. Mantell (Thoughts on Animalcules), though I have never seen it so largely developed as is represented in his figures. The young animal, having chosen a permanent resting-place, commences the formation of its singular investing case. I have verified Dr. Mantell's account of the position occupied by the first-formed spheres. They are arranged in a ring round the middle of the body, and are for some time unattached to the leaf or stem which supports the animal. They appear to have some internal connection with the thin membraneous cylinder (32 *a*). At first, new additions are made to both extremities of the enlarging ring. But the jerking contractions of the animal at length force the caudal end of the cylinder down upon the leaf, to which it becomes securely cemented by the same viscous secretion as causes the little spheres to cohere. All the new additions are now made to the free extremity, which, as Ehrenberg remarks, never extends beyond the level of the cloacal aperture of the outstretched animal. At its attached base, the cylinder consists of closely fitting hexagons (33) 1-1600th of an inch in diameter; but as we approach the opposite extremity, they become perfect spheres (34) (1-1100th of an inch in diameter), each one touching six surrounding ones, by six corresponding peripheral points. Small triangular spaces intervene, occupied only by the transparent secretion which glues the little spheres together. The fully-matured animal maintains its position within this case by means of its caudal prolongation, the extremity of which can be more or less flattened out into a suctorial disc (20 *c*).

From the above description it will be seen that the Melicerta ringens, one of the most highly organised of the Rotifera, does *not* pass through any larval form, in which it is represented by some of the simpler polygastric Infusoria. Though its external appendages, and especially the rotatory organs, are imperfectly developed at its birth, the organization as a whole is complete and final. The parts are all present, and only require to be expanded by the ordinary process of growth.

We have no metamorphosis such as is common amongst the Articulata: I have not even seen any evidence that the creature casts its skin. This fact was noticed by Dutrochet, and his observation appears to be correct.

When the ova are discharged from the cloaca they successively fall into the cavity of the tessellated case, where they undergo their further development. I have often found as many as four in one case, in the various stages of progress represented by figs. 12 to 16. It is whilst the eggs are thus protected that the young animals burst their shells—swimming out at the free extremity of the case as soon as they are liberated. When the ovum escapes from the cloaca its yolk usually consists of a single segment. In one instance only it had divided into eight whilst within the ovary. A second ovum is frequently seen progressing towards development whilst a fully shelled one is retained in the ovarium. Respecting the process of fertilization we know nothing. The two tubes which I have referred to as being possibly spermatic ducts are the homologues of similar ones in other Rotifera, to which Ehrenberg has assigned fertilizing functions. *Melicerta ringens* countenances his opinion on this point, though it does not prove it. I have seen nothing resembling spermatozoa.

In the possession of so highly organised a form of voluntary muscle, in the investment of the fasciculi by a sarcolemma, and in the existence of a well defined ciliated cellular epithelium lining the alimentary canal, we have indications of an organization approaching that of the lower Articulata. The dental apparatus appears to constitute a splanchno-skeleton like that of the Crustacea; but, on the other hand, the absence of a visible nervous system removes the *Melicertæ* far below the Homogangliate animals. That they should possess a nervous system of some kind appears almost a matter of necessity, if the presence of striated muscular fibre indicates volition; but its actual existence has yet to be demonstrated.

I have found no special organs of circulation or respiration. On watching the movements of the small free cells which float in the visceral cavity, as well as in the tail (14 *p*), it becomes obvious that the fluid contained within the integument moves freely with every contraction of the body. I detect no vessels or pulsating organs. These facts also tend to associate the animal with the lower Nematoneura, if not even with the Acrita, rather than with the Homogangliate Crustaceans. At the same time its organization is of a higher type than that of the Bryozoa.

Any attempt to establish the existence of homologies between the phenomena attending the development of the ova in the

Melicerta and those of the higher Mammalia may be deemed premature and unwise. Nevertheless there are some points in which a close relationship appears to be displayed. These affinities will be best traced by proceeding backwards from a stand-point where the homology is clear and definite. The yolk of the matured egg of Melicerta is the obvious homologue of the yolk of the Mammalian ovum. The circumstance that the entire yolk of the former enters *directly* into the composition of the young embryo, by a process of segmentation, instead of *indirectly* and through the medium of a germinal membrane, does not materially affect the case. The granular yolk of the *Melicerta* still corresponds with some early states of the granular yolk of the Mammalian ovum. In the latter case each Graafian vesicle is filled with granules, along with some nuclei, floating in a colourless fluid. Amidst these, the germinal vesicle, with its contained nucleus or germinal spot, is developed. After a while some of the granules and a portion of the fluid in which they float are attracted around the germinal vesicle, and thus form the yolk. All this corresponds with what takes place in *Melicerta.* The entire sac of the ovary in the latter resembles a large compound Graafian vesicle distended with fluid, in which there float numerous granules, as well as twenty or thirty nucleolated vesicles. or nuclei ; each of these nuclei successively attracts around itself a portion of the granular fluid to form the granular yolk, and the thickened shell may perhaps be regarded as the vitelline membrane, though this latter idea is not free from some objections. Bischoff has observed that, as the Mammalian ovum advances towards maturity, the number of the granules increases, and hence the yolk is more opaque in the mature, and more transparent in the immature ovum. This is precisely identical with the changes undergone by the yolk of the *Melicerta*, as described in the preceding pages. We may conclude from this comparison, that the elements which are contained in and solely occupy the ovisac of the *Melicerta*, are those which in the ovaries of the higher mammalia are restricted to the interiors of the Graafian vesicles; that whilst in the former case the protoplasmic stock forms one undivided mass, from which portions are successively pinched off to form the ova, in the latter examples it is divided into small portions, each being contained within a special receptacle, or Graafian vesicle ; the interspaces being occupied by the stroma or tissue of the ovary.

SINCE recording the preceding observations, I have had the advantage of perusing Mr. Huxley's instructive paper on

Lacinularia. I have verified Mr. Huxley's observation of the existence of *two* circlets of cilia, fringing the double margins of the sinuated wheel-organs; one being larger than the other. The larger one passes round the fissure dividing the two larger lobes, and consequently above the mouth. The smaller one, which is most external, passes below the mouth, being continuous with the ciliæ which fringe the "chin" of Mr. Gosse, the "fifth wheel-organ" of the preceding memoir. The food *that reaches the mouth* is whirled round the wheel-organs along the groove that separates the two circlets of cilia; and since these circlets diverge near the "chin," the mouth being located between them, the food is necessarily conveyed directly to the latter organ. The two sets of marginal cilia, by bending towards each other whilst in motion, almost convert this groove into a sinus, especially in the two larger segments. I had previously noticed the outline formed by the outer and smaller of these margins, but regarded it as merely a thickened portion of the disk, to the *surface* of which I erroneously imagined these additional cilia to be attached. On each side of the oral aperture there project two small flattened lobes with ciliated margins, continuous with those of the chin, and which obviously assist in directing the food into the œsophagus.

Between the mouth and the œsophageal bulb, on the same side as the ovary, is the transparent ball of horn-like substance referred to by Mr. Huxley; within the œsophagus, near its junction with the pharyngeal bulb, the ciliated lining membrane appears to hang in several loose, vibratile, longitudinal folds. I do not feel satisfied respecting the functions of the "nervous ganglion" of Mr. Huxley. I see no sufficient reasons for assigning to the small organ in question nervous functions. Of the ciliated sac of Mr. Gosse I have obtained some faint glimpses, not having been so fortunate as to see the animal when engaged in its architectural occupations; when not so engaged the sac becomes so contracted as to be almost invisible.

The singular bodies resembling spermatozoa exist in various parts of the organism, where they are apparently enclosed within hollow canals. I have never seen them occupying the two main trunks of the "water vascular system," or cæca, nor can I succeed in tracing any connexion between them. In several cases I have seen one or two of these curious bodies opposite the centre of the upper stomach, very near to, but independent of, the main cæcal canal, and at some distance below the point where the latter probably subdivides into branches. Near the neck there are usually from two to three pairs. Their vibratile motion ceases the moment the animal is killed by pressure. This fact does not countenance the idea that they are spermatozoa.

Two or three pyriform glandular (?) looking bodies are often attached to the base of the upper stomach, near the constriction which separates it from the lower one. Similar but larger bodies are seen in the neighbourhood of the œsophagus. Not having been able to trace any ducts or orifices passing from these organs to the viscera, I have hesitated to assert their glandular character.

In one example of *Melicerta*, the membranous ovisac was contracted and empty, containing neither protoplasm nor nuclei. Is this accidental, or may it have been a male animal?

On the Structure, Functions, Habits, and Development of MELICERTA RINGENS. By P. H. GOSSE, A.L.S.

BY the courtesy of Mr. Matthew Marshall I was favoured, on the 27th of May, 1851, with some fragments of *Lemna trisulca*, and other aquatic weeds, from a large glass jar, swarming with *Melicerta* to such an extent that sixty or seventy are crowded on a single leaf. They are very distinctly appreciable to the naked eye, for many of the tubes are 1-24th of an inch long, and when the animals are expanded, they reach to about 1-20th of an inch. They are set on both surfaces of the leaves. The tubes contain about thirty-two rows of pellets; each pellet is surrounded by six others; the rows are straight and uninterrupted perpendicularly, but transversely they are zigzagged, and the regular course is diagonal. Each pellet, examined separately, is of a yellowish or olive colour, composed of granules, and rather oval than round: the whole tube is of a reddish-brown. In old ones the surface is studded with *Confervæ*, *Diatomaceæ*, *Podophryæ*, and other extraneous matters, even to the summit. By picking to pieces the tube with the points of needles under a small microscope, I can readily extract the animal; it is often hurt by the process, but generally it is sufficiently whole to display the organization. Fig. 12, plate II., is one so extracted. The tubes or spurs on each side of the head below the chin are evidently consimilar with the antennæ of *Rotifer*, &c. There is a slender piston in each, capable of being retracted and protruded, and bearing at its extremity a tuft of very fine, divergent, motionless hairs.

The jaws are very complex, and differ so much in different aspects, that they are difficult to understand. Viewed *in situ* their appearance is as at fig. 16, or that of a single one examined carefully, as at fig. 17; but, under pressure, they become turned half-round, and appear as at figs. 18 and 19. In figs. 20 and 21 these two aspects are reconciled, the corresponding parts being lettered alike, according to my belief. The oblique projection (*d*) appears conspicuous in a side view, as shown *in situ* in fig. 20. These parts are enclosed each in a globose transparent muscle (?), by whose action the form is much altered; the points of the teeth (*a*) are drawn forward and downward, or *vice versâ*, and the part (*b*) seems to be lengthened and variously modified in form. A filmy line, more or less obvious, connects the point *b* (in fig. 20) with its fellow in the opposite jaw in some unintelligible way (see fig. 16). The action is not exactly that of two flat-surfaced mullers working on each other in a grinding manner, but a complex motion, impossible to be explained by words. Below the two globose lobes there is another rounded lobe (see figs. 16 and 18) equally hyaline, and probably muscular, which seems united to the two others, and alters in form as they and the jaws work, lengthening downward as they approach, and dilating and shortening as they recede. A slender œsophagus leads down to the gizzard, through whose lower part water is continually percolating, as it appears; but perhaps the appearance is caused by ciliary waves. Below the gizzard extends a long, wide cylindrical stomach; it apparently embraces the gizzard at its base without an appreciable tube; a large globose gland (see fig. 12) is probably one of a pair of pancreatic glands. The walls of the stomach are thick, and the food is received into a central tube, whence it passes into a globose intestine, the interior of which is covered with minute cilia. From the lower part of this viscus a slender but dilatable rectum turns up, and proceeds forward toward the occiput, till it terminates on the dorsal surface, just below the level of the gizzard. The cloacal outlet is capable of being greatly protruded, and this takes place in the moment of discharge, in order to shoot the fæcal mass out of the case, for it is then projected from above the rim. The fæces are slightly coherent and jelly-like, not at all like the case-pellets. The ventral region is, as usual, occupied by the ovary, sometimes granular and clear, at others filled with a dark maturing ovum. The head-mass, when retracted as in fig. 12, appeared separate and removed from the outer integument, and to be drawn together in a puckered manner. It descends into a small conical tubercle behind the gizzard, and between this and the base of the stomach there was one little tremulous tag, of the same structure as in *Notommata aurita*. From the same spot also project, into a space of peculiar clearness, two trumpet-shaped bodies of the greatest delicacy, and without motion (See fig. 12).

From far up in the trunk long muscular cords descend and pass into the foot, which they entirely traverse. This long organ is corrugated into close, irregular, transverse wrinkles; and there seem to be annular muscle-rings, exceedingly numerous throughout. The tip of the foot is not cleft, but it has a retractile disc, doubtless a sucker, if this be the principle of its adhesion; but near the tip, on its ventral side, there appeared a little granular body connected with the tip by a point, and enlarging at the upper end, where it was connected with a small globular vesicle. (See fig. 22.) Can this be a secerning gland for the secretion of an adhesive glue, by which the foot adheres, as in *Monocerca?*

Opening one or two cases I freed one and another very curious egg-like bodies (fig. 23), not symmetrical in shape, being much more gibbous on one side than the opposite, and measuring 1-150th by 1-260th of an inch. Each was encircled by five or six raised ribs, running parallel to each other longitudinally, somewhat like the varices of a Wentle-trap. Viewed perpendicularly to the ribs the form is symmetrical—a long, narrow oval. The whole surface between the ribs appeared punctured or granulate, and the colour was a dull brownish yellow. Under pressure it was ruptured, and discharged an infinity of atoms of an excessive minuteness, but every one of which, for a few seconds, displayed spontaneous motion. Their whole appearance, and the manner in which they presently turned to motionless disks, were exactly the same as of the *Spermatozoa*, which the male eggs of other Rotifera contain, except that these were so minute.

From another I extracted an egg of the ordinary form and appearance (fig. 24). It was very long, measuring 1-145th by 1-390th of an inch. The contained embryo was well advanced; two red eyes were plainly seen by reflected and by transmitted light: the gizzard was transverse, very large in proportion, and the jaws worked vigorously; a little opaque body, white under sunlight, was in the posterior part. This embryo died without hatching.

May 30.—A young one, about half adult size, was attached by the base of its tube to the side of the tube of an adult, near the summit of the latter, so as to project obliquely upward. This specimen, which was perfectly formed, gave me an excellent opportunity for observing the ventral aspect (see fig. 14), and the dorsal (fig. 15). It had two red eyes, one placed near the base of each larger petal. I could not discern eyes in adults. It was very energetic, diligently engaged in manufacturing the pellets and laying them on. It seems that the action of the pellet-cup is voluntary, and not always coexistent with the passing of the ciliary current over the chin. The animal frequently makes abortive efforts to deposit a pellet, and sometimes bends forcibly forward to the edge of the case before the pellet is half formed. The chin forms a projecting lobe, apparently concave at the tip, spoon-shaped or tubular (see fig. 13), well covered with cilia, which carry on the current from the great sinus. The petals are evidently thick in the middle, and I think are very abruptly attenuated from the ring of nervous (?) matter that runs round them, to the margin. The wheel-cilia have their bases on this ring, and not on the margin (see fig. 15); a very delicate granular mass runs out in a point from the base to the centre of each petal; this may be cerebral, and the rings muscular. The edges of the petals are contracted, corrugated, incurved, and folded together at the will of the animal. Between the two larger petals is the mouth, for in the lateral view (fig. 13) a rather wide pharynx was distinctly seen extending from that point to the summit of the gizzard, and minute particles were traceable through it, which were rapidly poured between the jaws. The lower portion of this duct is seen also in fig. 14. The breast, between the diverging antennæ, forms several irregular rounded lobes, and below the gizzard it is constricted laterally.

There is a very close affinity between *Melicerta* and the *Philodinadæ*, say, for example, *Rotifer citrinus.* The wheels are sinuous instead of round, but the great sinus and projecting spoon-shaped chin are in both; the antenna, single and medial in *Rotifer*, is repeated and thrown apart in *Melicerta*, but the structure is identical. The gizzard is essentially the same—a pair of muscular hemispheres with hard transverse teeth: the stomach and intestine are the same; and the upward direction and production of the rectum are but trivial modifications dependent on a tubicolous habit. The structure of the foot is, however, nearer to that of *Brachionus*, or perhaps *Pterodina*, being corrugated, not telescopic-jointed, and terminating in a sucker, not in toes; but this again is a tubicolous modification.

May 31.—On looking into the live-box, in which were several tubes, I found a young one swimming rapidly out in a giddy, headlong manner. I believe it was just hatched. Its form was somewhat trumpet-shaped, or like that of a *Stentor*, with a wreath of cilia around the head, interrupted at two opposite points. The central portion of the head rose into a low cone. After whirling about for a few minutes, its motion became retarded, and it began to adhere momentarily, and to move forward by successive jerks, not more than its own length at once. The periods of its remaining stationary increased, so that I several times supposed it had taken up its permanent position, when some shock or alarm would send it off for a little distance again. At length, about an hour after I first saw it, it finally settled, adhering by the foot to the lower glass of the box. Fig. 25 represents the ventral, fig. 26 the dorsal outline of this young one, but more I could not sketch, for after a few rapid gyrations upon the foot as a pivot, it became vertical, and appeared to the eye looking down on it, as at fig. 27. The form of the adult was now distinctly assumed, the four petals of the disk were well made out, though the sinuosities were yet shallow: the antennæ at first were only small square nipples (fig. 27, *a a*), but soon shot out into the usual form; the ciliated chin was distinct, as was also the whirling of the pellet-cup immediately beneath it. A pellet was quickly formed, and instantly deposited at the foot; the same operation was repeated with energy and industry, so that in a few minutes a row of pellets were seen, forming a portion of a circle around its foot-base, as shown at fig. 27, *b*. When two or three rows were formed, I took occasion to measure the time of their construction; one pellet was deposited every minute with great regularity. I mixed a little carmine with the water: the result was beautiful; for the dark torrent that poured off in front, and the appearance of a rich crimson pellet in the cup (fig. 27, *c*), were instantaneous. Yet the imbibition seemed deleterious; for the animal would withdraw itself suddenly, after a revolution or two, and presently retired sullenly, having laid five or six carmine pellets, whose deep tints made them conspicuous on the pellucid yellowish ones. Some three hours after, I saw that no more were laid. But in the course of the night the case was considerably increased with carmine; the part so made was much less regularly formed of pellets than that composed of the natural material, for the red portion was all confused and blended as it were into a mass, without distinction of pellets, though retaining the tubular form.

A large one, whose case had become accidentally injured near the base, so as to be slit for some distance up, protruded itself through the opening, remaining still attached by the foot. It did not again enter, but continued for several days, carrying on all its functions in the healthiest manner, exposed. It frequently made pellets, but these were never deposited, but allowed to wash off into the water, nor was any attempt made to construct a new case. A half-grown one, very active, that was near, deposited pellets only rarely, eight or ten in several days; whence it appears that this process is quite voluntary: indeed, if it were not so, so rapid is the formation, that the tube would be increased beyond all bounds in a very brief period of the animal's life.

The process of swallowing carmine enabled me to see very distinctly that (as shown at fig. 14) the œsophagus enters the gizzard between the larger ends of the jaw-mullers, and that the stomach-duct leads off from their smaller ends, through the semi-globular lobe beneath. This duct, though short and wide, is distinct.

June 12.—The young one obtained May 30 was active till this morning, when it suddenly died, having lived in confinement fourteen days. During the whole time it has scarcely increased in size, nor has it added any pellets to its case, except a few the first day or two. The eyes were distinctly visible to the last.

Remarks on the Cornea of the Eye in Insects, with reference to certain sources of fallacy in the ordinary mode of computing the Microscopic hexagonal Facets of this membrane: with an Appendix, containing a brief notice of a new method of taking transparent Casts of the above, and other objects for the Microscope, in Collodion. By John Gorham, M.R.C.S.L., Fellow of the Physical Society of Guy's Hospital; Honorary Fellow of the Royal Botanic Society of London, &c.

The eye of the Insect tribe has been chosen for the present communication, not only from its great beauty and wonderful organization, but on account of its transparent portion (cornea) presenting a multitude of well-defined planes, forming a reticulation which is especially calculated to excite our admiration. It is to this, therefore, and not to the interior, that our attention will be chiefly directed.

On examining the head of an insect we shall find a couple of protuberances more or less prominent, and situated symmetrically, one on each side. Their outline at the base is for the most part circular, elliptical, oval, or truncated; while their curved surfaces are spherical, spheroidal, pyriform, &c.

These horny, rounded, naked parts seem externally to represent the corneæ of the eyes of Insects; at least they are appropriately so called from the analogy they bear to those transparent tunics in the higher classes of animals. They differ from these latter, however, in this respect, that, when viewed by the microscope, they display a number of hexagonal facets which constitute the media for the ingress of light to as many simple eyes. Under an ordinary lens, and by reflected light, the entire surface of one of these corneæ presents a beautiful reticulation, like very fine wire gauze, with a minute papilla, or, at least, slight elevation in the centre of each mesh. These are resolved, however, by the aid of a compound microscope, and with a power of from 80 to 100 diameters, into an almost incredible number, when compared with the space they occupy, of minute, regular geometrical hexagons, well-defined and capable of being computed with comparative ease, their exceeding minuteness being taken into consideration. When viewed in this way the entire surface bears a resemblance to that which might easily and artificially be produced by straining a portion of Brussels lace with hexagonal meshes over a small hemisphere of ground glass. That this gives a tolerably fair idea of the intricate carving on the exterior may be further shown from the fact that delicate and beautiful casts in collodion* may be procured from the surface by giving this three or four coats with a camel's-hair pencil. When dry it is peeled off in thin flakes, upon which the impressions are left so distinct, that their hexagonal form can be discovered with a Coddington lens. This experiment will be found useful in examining the configuration of the facets of the hard and unyielding eyes of many of the Coleoptera, in which the reticulations become either distorted by corrugation or broken from the pressure required to flatten them. It will be observed, also, that by this method perfect casts of portions of the cornea can be obtained without any dissection whatever, and that these *artificial exuviæ*, for such they really are, become available for microscopic investigations; obviating the necessity for a more lengthened or laborious preparation.

But to return. The dissection of the cornea of an insect's eye is by no means easy. I have generally used a small pair of scissors, with well-adjusted and pointed extremities, and a camel's-hair pencil, having a portion of the hairs cut off at the end, which is thereby flattened. The extremity of the cedar handle, on the other hand, is shaved to a fine point, so that the brush may be the more easily revolved between the finger and thumb, and the coloured pigment on the interior may thus be scrubbed off by this simple process. A brush thus prepared and slightly moistened forms, as far as my experience goes, by far the best *forceps* for manipulating these objects preparatory to mounting; as, if only touched with any

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* A solution of gun-cotton in chloroform. It can be procured of any chemist.

hard-pointed substance, they will often spring from the table from mere elasticity, and thus the labour of hours may be lost in one single moment. It does not appear to me desirable to attempt to flatten an *entire* cornea by pressure and maceration, although I am aware this is generally recommended, but no useful purpose is really served either in developing the beauty or counting the number of its lenses. The rounded membrane, on the other hand, becomes, as might be anticipated if the margin remains intact, corrugated, and so one hexagon overlaps the other. It will be useful, therefore, to make two preparations of the eyes of one insect, the one entire, retaining its naturally curved form, not having been subjected to any pressure—the other nicked at its margin, or cut into small fragments and pressed flat between two slides.

Each of the hexagons above-mentioned is itself the slightly " convex horny case of an eye. Their margins of separation are often thickly set with hair, as in the Bee; in other instances they are naked, as in the Dragon-fly, House-fly, &c. The number of these lenses has been calculated by various authors, and their almost incredible multitude has very justly excited astonishment. Hooke counted 7000 in the eye of a House-fly; Leeuwenhoek more than 12,000 in the eye of a Dragon-fly, and 4000 in the eye of a domestic fly; and Geoffroy cites a calculation, according to which there are 34,650 of such facets in the eye of a Butterfly."

Having carefully examined with the microscope a small flattened portion of the eye of a Dragon-fly and a few analogous specimens, we are, I think, in a position to assume two things which will serve to form the basis in our calculations:—

1st. That the reticulations referred to are composed of perfect, regular, geometric hexagons; and

2ndly. That the hexagons are all of equal size.

Their number, in any individual specimen under investigation, might, of course, be ascertained by actual enumeration; the process however would be a very laborious one, and injurious to the sight. Leeuwenhoek computed them by assuming the prominent part of the eye to be hemispherical.* He then counted a single row of hexagons from the summit to the base, and this multiplied by four gave the great circle of a sphere, the area of which was then discovered by a simple arithmetical process. It will be observed, however, that those eyes only, the surface of whose common cornea is hemispherical (and there is a large number in which it is not), can be treated in this way; and, if the facets could be

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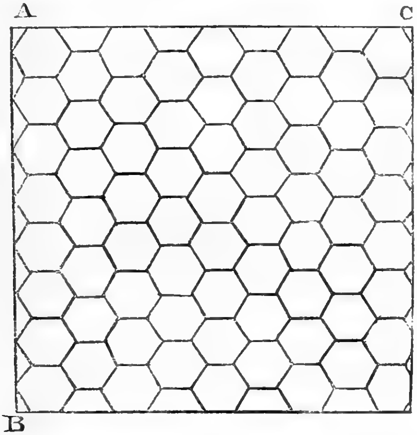
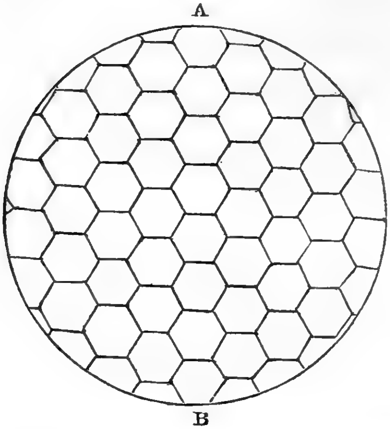
* The eye under examination was that of the Moth of the Silk-worm.

thus computed, the results would be incorrect according to the method of Leeuwenhoek; inasmuch as in all his calculations the hexagons were reckoned as squares: thus many hundred were lost even in one single eye. Having pointed out this source of fallacy, we proceed to endeavour to correct it.



A mere inspection of the above square area of hexagons will show that such an outline, enclosing as many regular hexagons of a given size as it will contain, has a less number on the one side, A B, than on its adjacent side, A C. A closer examination will discover that these numbers bear a ratio of 8 : 9.25, or of 1 : 1.156; while, if the entire area is counted, not omitting the portions which are truncated by the sides of the square, it will be found about 74 (or 8 × 9.25). Those numbers are not, indeed, mathematically correct, but sufficiently so for our present purpose; for, doubtless, we have not failed to notice that if the side, A B, had been squared in the ordinary way (8 × 8), and not treated as if it were composed of hexagons (8 × 9.25), we should have lost as many as ten planes even in a space containing so few hexagons; and these will vanish by hundreds instead of tens, as the area increases.

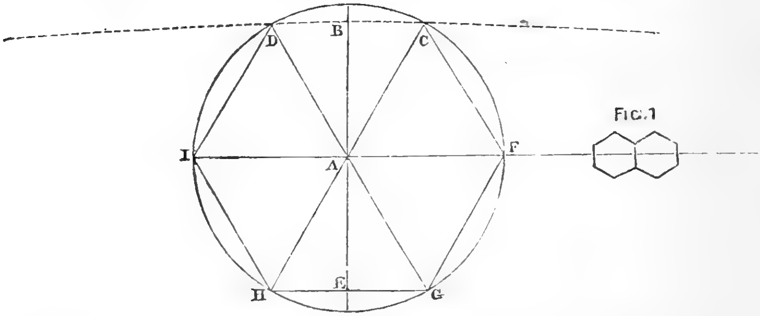
And, if we take a circle with a row of hexagons passing through its great diameter, A B, and calculate from this the entire number spread over its whole superficies, we shall soon discover how very far wide of the truth our results would be, supposing the hexagons were treated as squares. For, first, let it be required to find the area of a circle in *squares* with any number, say twenty, composing its diameter. Now, the



square of the diameter × .7854 = the area: hence $20^2 \times .7854 = 314.160$ the area in squares.

Again, given a circle whose diameter = 20 regular hexagons, arranged with their sides in apposition (fig. 1), to find the area in hexagons. Now, as circles are to one another as the squares of their diameters, and as we have already seen that a square of hexagons = the product of 8 : 9.25, or numbers in that ratio, we have:—8 : 9.25 : : 20 : 23.125. Hence $20 \times 23.125 = 462.5$, the diameter squared, and $462.5 \times 7854 = 363.247$ the area in hexagons.

Or a circular area of hexagons may be thus found:—



Given: a circle with twenty small hexagons (arranged side by side, fig. 1) passing through its great diameter, to find the area.

The circle of the circumscribing circle will pass so close to the side C D (fig. 2) of the hexagon, that we may safely call

$E\,B = \frac{1}{20}$ of the diameter. Now evidently $\frac{\text{area of circle}}{\text{area of hexagon}} =$ number of hexagons; we have therefore to find area of hexagon.

$$B\,C^2 = A\,C^2 - A\,B = 4\,B\,C^2 - A\,B^2$$

$$3\,B\,C^2 = A\,B^2$$

$$B\,C = \frac{A\,B}{\sqrt{3}}$$

area of triangle $A\,B\,C = B\,C \times A\,B = \frac{A\,B^2}{\sqrt{3}}$

area of hexagon $= 6\,\frac{A\,B^2}{\sqrt{3}} = 2\,A\,B^2\sqrt{3} = 2.\left(\frac{1}{40}D\right)\sqrt{3} =$

$\frac{1}{800}\,D^2\sqrt{3} = .00125.\quad D^2\ 1.73025$

area of circle $= .7854\ D^2 = .0021650625\ D^2$

$\frac{\text{area of circle}}{\text{area of hexagon}} =$ no. of hexagons $= \frac{.7854}{.002165} = 363$ nearly.

From these and analogous calculations, tables might be constructed for all possible dimensions of the square and the circle, the side being given in the former case, and the diameter in the latter:—

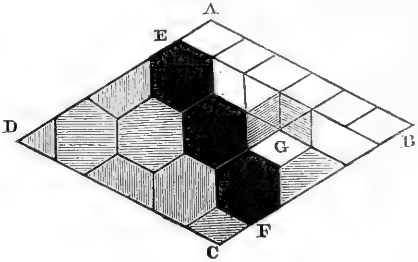
SQUARE.

Side.	Area in Squares.	Area in Hexagons.	Difference.
10	100	115.625	15.625
20	400	462.500	62.500
30	900	1040.625	140.625
40	1,600	1850.000	250.000
50	2,500	2890.630	390.630
100, &c.	10,000	11562.500	1562.500

CIRCLE.

Diameter.	Area in Squares.	Area in Hexagons.	Difference.
10	78.540	90.811	12.271
20	314.160	363.247	49.087
30	706.860	817.306	110.446
40	1256.640	1452.990	196.360
50	1963.500	2270.300	306.800
100	7854.000	9081.875	1227.875

A few only are necessary in this place; but even in these the columns of *difference* sufficiently indicate the loss likely to follow from miscalculation. I pass on to notice, however, that the only quadrilateral figure which will so contain a number of hexagons that its area may be discovered by squaring a side, is a *rhomb* of 60° and 120°; that is to say, two equilateral triangles placed base to base. When such a plane is occupied by regular hexagons, any side, A B, may be supposed to consist of small rhombs ranged side by side, each being exactly one-third (G) of one of the enclosed hexagons. All the sides are alike; hence it follows that, if one of them be multiplied into itself, and the product divided by three, the area of the rhomb, A B C D, in hexagons, is determined.



Let A B = 6 rhombs, then $\frac{6^2}{3} = 12$ the number of hexagons in A B C D. But the sides themselves are deduced from a single row of hexagons E F extending across the rhomb perpendicularly with respect to A D and B C; and it is to be remarked that the number of rhombs in a side is always double of that of the hexagons composing this perpendicular series. In the figure there are three such hexagons E F, and consequently six rhombs in a side. The hexagons can always be calculated therefore by the formula

$$\frac{(a \times 2)^2}{3}$$

where a represents the number of hexagons in the perpendicular series. Let $a = 3$ then $\frac{(3 \times 2)^2}{3} = 12$ the area of A B C D.

Allusion has been made to Leeuwenhoek's calculations of the lenses of the silkworm's eye. These may now be corrected.

The number of facets, counted from the base to the summit of the hemispherical cornea, in the eye of the silkworm moth, is thirty-five. But a single row, extending over a space = one quarter of the great circle of a sphere, × 4 = the circle itself, or 140. Now, the area of a sphere = four times the area of its great circle, and the area of a great circle = the square of the diameter × .7854. Again, the great diameter = the circumference ÷ 3.1416. Thus,

$$\frac{140}{3.1416} = 44.563 \text{ - - - - - diameter of the circle}$$

$$44.563 \times 51.525 \text{ (i. e., in the ratio of } 8 : 9.125) = 2296.108 \text{ - - - - - squares of diameter in hexagons}$$

$$2296.108 \times .7854 = 1803.363 \text{ - - - area of circle}$$

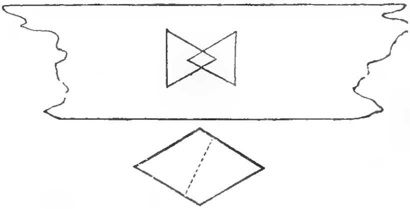
$$\text{and } 1803.363 \times 4 = 7213.452 \text{ - - area of sphere in hexagons}$$

$$\frac{7213.452}{2} = 3606.726 \text{ hexagons in superficies of one hemisphere or eye.}$$

Spherical area according to Leeuwenhoek, with the hexagons counted as squares	= 6236
Spherical area computed as above, with the hexagons considered as such	= 7213

Number lost by Leeuwenhoek = Difference - - - 977.

We have seen how easily a surface of hexagons, whether it be circular or hemispherical, square or rhombic, may be computed from a single row; and we have now to procure sections of eyes, presenting such shapes for inspection under the microscope. To excise small fragments from such minute and fragile membranes, and those of regular and determinate figures, requires nice manipulation. The quadrilateral figures I have been in the habit of making, by enclosing the membrane between two pieces of gummed white paper, upon one side of which the parallelograms are drawn; they are then cut entirely through with a penknife, and soaked for a short time in cold water, which softens the gum, and thus separates the paper. Circular sections are made with a small punch, after having been enclosed between paper as above recommended. On the surface of a small circle of the eye of a Dragon-fly, excised with the smallest saddler's punch, marked No. 1, I have counted about 800 facets; in another, a size or two larger, about 5000, and so on. I have not felt satisfied with many of these preparations, however, although several have come out very well. Their edges are often lacerated by the punch, while the parallelograms, when magnified, have presented considerable deviations from the true parallel. These inconveniences are obviated by making small apertures, of the required shape and size, in black paper, which are placed immediately over the specimens to be examined. The circular openings can be punched out, while the others can be removed with a sharp knife. A simple and not inelegant mode of procuring very small rhombic apertures, perfectly equilateral and equiangular, consists in excising two small equilateral triangles from two slips of black paper, and sliding one over the other until the small rhomb in the centre, produced by their mutual intersection, is of the required size. The cornea is placed under this rhombic aperture, and the lenses are viewed and counted through it, by merely enumerating one row extending in a perpendicular direction, with respect to any two opposite or parallel sides, and joining them as in the dotted line of the annexed rhomb.



Appendix.

This is the first time, I believe, that the collodion has been employed in the production of transparent membranes for microscopic purposes. There are reasons for supposing that it will enable us to construct a series of novel and highly interesting preparations, by its presenting the minute tracery observed on the surface of many opaque objects in a transparent form. In this way we can *multiply* impressions of specimens which are very beautiful or very rare. It bids fair, also, to put us into possession of the general configuration on the surface of certain minute fresh vegetable structures which become shrivelled, and their beauty obliterated in drying. It is best applied as follows:—A few chips of Red Sanderswood are shaken up in a drachm or two of good collodion; the surface of the object is then painted over four or five times, and in less than ten minutes the flake or cast of collodion can be peeled off, and mounted on a slide under a thin cover as a dry preparation.

Remarks on the Preparation of the POLYPIDOMS *of* ZOOPHYTES *for Microscopical Examination, with a notice of the phenomena they exhibit with polarized light. By* GOLDING BIRD, A.M., M.D., F.R.S., *Fellow of the Royal College of Physicians.*

ALMOST every miscroscopic observer is familiar with the extreme beauty of the horny polypidoms of the Anthozoa, and the calcareous structure of the Polyzoa, when examined as transparent objects in their recent state. There are few persons who have not regretted the extent to which these become disfigured by drying, so as to afford hardly an idea of the elegance which had previously rendered them so attractive. The failure of all attempts to preserve them in balsam and restore them to their original transparency and sharpness of outline induced me, during a recent visit to the coast of Pembrokeshire, to try some experiments in the hope of overcoming this difficulty, which have yielded some interesting results.

The great obstacle to preserving these structures in balsam arises from their retaining, when dried, air in their tubes and cells so obstinately that it is hardly practicable to get rid of it, as well as from their shrivelling up in the process of drying. By the following plan I find the polypidoms may be preserved as permanent preparations, retaining the appearance of the most beautiful recent specimens, wanting only the expanded tentacula of the former inhabitants of their cells to complete the appearance they present when living in their native seas.

The specimens should, if possible, be preserved in weak spirit until leisure is afforded for their preparation: if, however, they have been dried, they should be soaked in cold water for a day or two before being submitted to the following processes.

1. Select perfect specimens of the proper size for the microscope, which in the larger zoophytes should not exceed two inches in length. Immerse them in water, heated to 120°, in a glass cylinder, and place them under an air-pump receiver. Slowly exhaust the air; torrents of bubbles are given off from the surface of the tubes and cells, and very soon the water will appear to be in a state of active ebullition. In a few minutes re-admit air into the receiver, and after a short time again exhaust; repeat this three or four times. By this process the air is removed from the cells and tubes, watery vapour taking its place; at the same time, by the repeated admission of water into them, and its removal during the process of exhaustion, the internal structure of the poly-

pidoms becomes freed from the dead polypes and other animal matter. With the exception of a few of the cellular Polyzoa, especially *Flustra foliacea* and *Gemellaria loricata*, I have never found any difficulty in thus removing every air-bubble.

2. The polypidoms should now be removed and allowed to drain for a few seconds on a piece of bibulous paper, and then placed in an earthen vessel fitted with a cover and previously heated to about 200°. The best thing for this purpose is one of the common, thick, white pots, with its cover, used used by druggists to hold ointment. These are so thick that they retain their temperature sufficiently long for the purpose required. They are most conveniently heated by boiling them for a few minutes in water, lifting them out with a pair of forceps, and hastily wiping them with a thick cloth. The specimens, being dropped into one of these vessels, and covered with the loosely-fitting lid, are then to be placed under the receiver of an air-pump, and the air rapidly exhausted. By this process the specimens are very quickly and completely dried, the water being evaporated from the cells and tubes so rapidly that they hardly collapse or wrinkle.

3. The specimens are to be removed in an hour or two from the air-pump, and dropped into a glass cylinder containing perfectly transparent camphine. This may be quite cold when the horny, tubular polypidoms, as those of the Sertulariæ, are used, but should be previously heated to 100°, when the calcareous, cellular Polyzoa are the objects to be preserved. The vessel, being covered with a large watch-glass, must be placed on the air-pump, and the air exhausted and re-admitted two or three times. After this the vessel may be set aside until it is convenient to place the specimens in balsam in the following manner:—

4. One of the slips of glass intended for each specimen should have a narrow piece of card-board fastened by a little glue to each end so as to prevent the subsequent injury of the structure from pressure. The slip thus prepared should then be carefully cleaned from any dust, and be held over a spirit-lamp to warm it sufficiently to allow the balsam to flow freely over it. This should be applied by means of a thick glass rod, so as to cover the glass with a large body of balsam. All air-bubbles must be carefully removed by a needle point in the usual way. Whilst still warm, the polypidoms (previously removed from the camphine and drained for a minute in a watch-glass) should be grasped by a pair of forceps and carefully immersed in the balsam. A second plate of glass, without the pieces of card, should be quickly warmed on the spirit-lamp, and a thin layer of balsam spread over its surface.

It must then be carefully placed over the specimen, by allowing one end to rest on one piece of card-board fixed to the slip of glass, and then gradually lowered. If this be adroitly done, not a bubble of air will be entangled in the preparation. The plates should then be gently grasped in the middle by the wooden forceps or fingers, and fastened together by means of the smallest quantity of sealing wax at each end. Slips of paper are to be carefully pasted round the sides and ends, and the preparation may then be preserved without injury.

Thus prepared, such specimens become the most beautiful of transparent objects for the miscroscope. Their translucency is as complete as in the fresh zoophyte. The structure of the cells and vesicles is most beautifully exhibited. Scarcely any more beautiful objects for the microscope can be thus obtained than those of the common *Sertularia abietina* and *operculata*. The vesicles in each are most interesting. The curious mouths of the former, and the opercular lids of the latter, are sure to arrest the attention. These objects are finely shown by a two-inch object-glass; the bird's-head processes of *Cellularia avicularia* require, however, an inch-glass; a deeper objective being very seldom required, except for making out very minute structures.

But it is when these objects are examined by polarized light that the most interesting results are obtained. For this purpose, let a piece of selenite be placed on the stage of the microscope, and the polarizing prisms arranged so that the ray transmitted is absorbed by the analyzer. Of course in the absence of the selenite, all light would disappear from the instrument, and none would reach the eye. On placing the selenite on the stage it will, if of proper thickness, allow an abundance of green light to be transmitted. Selenite which presents a bluish or violet tint when thus examined, is not so fitted for these observations.

If, then, a specimen of *Sertularia operculata* be placed on the selenite stage and examined with a two-inch object-glass, a most beautiful spectacle presents itself. The central stem is shown to be a continuous tube, assuming a more or less pink tint throughout its whole extent. The cells assume a bluish or sometimes violet tint, their pointed orifices, and, indeed, their whole structure becoming much more distinct than when examined by common light. The vesicles appear paler than the rest of the object, and their lids, which so remarkably resemble the operculum of the theca of a moss, being composed of a somewhat denser structure, generally assume a yellowish or orange tint, so that they become beautifully distinct. This zoophyte is often covered with very minute bivalve shells, distinguished by the naked eye from the vesicles only by their circular form, and these when present add much to the beauty of the specimen, presenting a striated structure, and becoming illuminated with the most brilliant colours.

Thus, when submitted to polarized light, the zoophyte becomes not only a most beautiful, but an instructive object, the relation of the cells to the tube which bears them, and the continuity of the latter being so readily seen. *Sertularia filicula* is also an interesting object, the waved stem or central tube becoming of a deep dusky red, whilst the cells assume but little colour, renders their mutual relation very obvious. *Sertularia abietina* is also a fine object, especially when loaded with vesicles as it so often is in the autumn. *Halecium halicinum*, perhaps the least elegant of this class of beings, assumes a very interesting appearance, its cells assuming a moderate amount of colour. The very beautiful *Plumularia falcata* acquires fresh beauty under polarized light; for although its cells do not become coloured, merely assuming a pale green, yet the tubular stem becomes more or less of a crimson hue, presenting the appearance of a beautiful feather. It is really remarkable how much more distinct every structure appears, and how much greater a charm is thrown over the elegant structure of the polypidoms when examined in the green light of the selenite. They seem almost, to an imaginative eye, to be once more in their native element.

The most splendid tints are exhibited by the calcareous structure of the Polyzoa, and among these the *Flustra truncata* is perhaps the most interesting. When a preparation of this zoophyte is examined by polarized light with a two-inch glass without the selenite, the structure of the cells, and the shape of their mouths, are well seen; but in several portions of the specimen the walls of the cells present the appearance of a tesselated pavement, several minute, spherical, coloured structures being scattered over it. On replacing the object-glass by one of one-half inch focus, these spherical bodies present the dark cross with beautiful tints in each quadrant, at first sight resembling the carbonate of lime I discovered some years ago in the urine of the horse. On examining them carefully, however, the polarizing structure will, in many of them, be found to be identical with that seen in the crystalline lens of the cod, or in a spheroid of unannealed glass when immersed in oil, and different from that of a slice of calc-spa or circular plate of unannealed glass. The centre of each spherule being occupied by a black cross with the tinted quadrants, the whole being circumscribed by a black circle. Beyond this extends a second set of black arms with more varied tints between them. A more interesting structure I have never had occasion to examine than that presented by these spherules of carbonate of lime. On placing the selenite plate under the specimens, the black cross and circle became green; and a very beautiful result occurs from some tints being raised, and others depressed, in the scale of colours. On digesting a piece of *Flustra truncata* in diluted hydrochloric acid, and then putting it upon balsam, like the fresh specimen, this beautiful structure disappeared; all appearances of tessellated tints and coloured spheres had vanished. Hence they depended upon the crystallized arrangement of the carbonate of lime.

The more common *Flustra foliacea* is an interesting object on the selenite stage, but does not exhibit the peculiar polarizing structure of the other species.

The *Cellularia avicularia* is a brilliant object with the selenite stage, its cells being covered with plates of carbonate of lime; it presents a fine display of tints, the bird's head appendages being exceedingly beautiful.

The *Gemellaria loricata* is one of the most beautiful objects with the selenite, the cells assuming a pale pink, and the obovate orifices of each—provided apparently with a frame of carbonate of lime to keep them patent—assumes a fine and rich orange tint.

I have alluded to some of the most beautiful of the structures which have occurred to me; but I feel sure, that those observers who have more time at their disposal, will add to our knowledge of the diversity existing between the polarizing structure of these polypidoms. I would especially draw attention to the curious spherules of *Flustra truncata;* they deserve a very careful examination. I was disappointed in not detecting a similar structure in the birds' heads of Cellularia.

I cannot close this little communication without alluding to an excellent and very simple plan for preserving the zoophytes as wet preparations, so as to retain the polypes and their tentacular arms *in situ.* Ellis stated nearly a century ago, that if the zoophytes were plunged into brandy so as to kill them speedily, they might be preserved for a long time. I find, however, that it is better to select a very vivacious specimen and plunge it into cold pure water—the polypes are killed almost immediately, and their tentacula often do not retract: proper sized specimens should then be selected, and preserved in weak alcohol. For this purpose little phials* about two inches long should be made, from very thin, flat glass tube, so as to be half an inch wide and about a quarter of an inch, or even less, from back to front. The specimens being

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* Mr. Pastorelli, of Cross-street, Hatton Garden, who has taken much pains to manufacture these little flat phials, supplies them at a very low price.

fixed to a piece of thin platinum wire, should then be placed in one of these flat phials (previously filled with weak spirit), so as to reach about half-way down. When several of these are thus arranged, they should be placed in a glass cylinder and removed to the air-pump. On pumping out the air, a copious ebullition of bubbles will take place, and many of the tentacula, previously concealed, will emerge from the cells. After being left *in vacuo* for a few hours the bottles should be filled up, closely corked, and tied over, like common anatomical preparations. I find that, for all examinations with a one or two-inch object-glass, these bottles are most excellent, and afford cheap and easy substitutes for the more expensive and difficultly managed cells. In this manner specimens of the genera *Cycloum*, *Membranipora*, *Alcyonidium*, and *Crisia*, exhibit their structure most beautifully.

A few dozen of these little bottles hardly occupy any room, and would form a useful accompaniment of the microscopist by the sea-side. Any one who would visit the caverns in St. Catherine's Island, at Tenby, could reap a harvest which would afford instruction and amusement for weeks. In these caverns, so rich in zoophytes and sponges that they are really roofed with the *Laomedeæ*, *Granticæ*, and their allies, whilst the elegant *Tubulariæ* afford a garden-like ornament to the shallow pools on the floor, the walls abounding with the pink, yellow, green, and purple *Actiniæ*, days may be spent with instruction and amusement of the most interesting kind. I have, indeed, been informed by my friend Mr. Dyster, of Tenby, who has devoted himself to the investigation of the inhabitants of these caverns with great zeal and success, that no locality affords, in the same space, such an abundant treat for the zoophytologist. I cannot too strongly recommend a visit to them, to all who have a few days leisure in the summer.

On the Embryogeny of ORCHIS MASCULA. By T. SPENCER COBBOLD, M.D., formerly Senior President of the Royal Medical Society of Edinburgh.

AFTER the elaborate memoir of M. Tulasne on the vegetable embryo in the 'Annales des Sciences Naturelles' for 1849, containing not only the results of his own extended investigations, but embodying a complete analysis of all that has been previously written on this subject, it is with diffidence that I offer the following details, which are chiefly confirmatory of facts already elicited. The reviewer of Professor Quekett's Lectures on Histology in the first Number of this Journal, page 44, hints that "the question of the entrance of the pollen tube into the sac of the embryo" is *still* one of interest to vegetable physiologists; this remark has suggested the present communication.

Of all the natural orders hitherto examined by the embryologist, few have been more closely studied or yielded more satisfactory results than the *Orchidaceæ:* the researches of Brown, Amici, Mohl, Muller, Hofmeister, and many others, are too well known to require recapitulation; our own inquiries have extended over a large number of *genera*, but the selection of a single species sufficiently demonstrates the question under consideration.

Referring at once to the illustrations, fig. 1. will be recognized as a floret of *Orchis mascula*, with the peduncle (*p*) and bract (*b*) attached. Before fertilization is accomplished, the peduncle (which encloses the ovarium) begins to enlarge, consequent upon the growth of the contained ovula. Plate II., figs. 2, 3, 4, and 5, indicate the successive stages of development of the ovula; their first appearance is only recognised by a slight bulging outward of the cellular parietes (placentæ) of the ovarian chamber, in the form of papillæ, which are the representatives of the nucleus of the perfect ovulum (marked *n* in all the figures). The mode in which the *primine* (*pr.*) and *secundine* (*se.*) are developed, and subsequently enclose the nucleus, is also well shown. Some time after impregnation has been effected, the condition of the ovary assumes the appearance seen in fig. 6, a section of which, slightly magnified, is given in fig. 7. Bundles of pollen-tubes (*pt.*) run along the inner side of the placentæ and terminate by short curves, entering the micropyles of the ovula (*ov.*); on the left side of the figure their distribution is well exhibited, the ovula being detached, and the pollen-tubes left pendant.

Examining the ovules at this stage, we now perceive a cavity in the centre of each nucleus; this is surrounded by a cell-wall, and constitutes the *embryo sac* (fig. 8, *es.*). In the interior of the *sac* granular matter exists in more or less abundance, being generally found thicker near the apex; but, whether or not distinct cytoblasts or embryonic vesicles exist prior to the contact of the pollen-tube with the embryo sac (as is indubitably the case in numerous other phanerogamia), is a point not fully determined. In those instances where we have witnessed the union of the pollen-tube with the embryo sac, the granular matter has usually been found collected together opposite the point of application (figs. 9 and 10), and, in one instance, three embryonic vesicles (*ev.*) were visible at the apex of the sac, the pollen-tube remaining firmly adherent (fig. 11). This latter observation, agreeing as it does with what we have ourselves observed in *Gesnerea*, and being also in accordance with the views advocated by all later authorities, we think we cannot better close this short paper than by drawing the following conclusions, which may be regarded as embracing the leading facts and particulars hitherto promulgated on this interesting subject:—

1st. That prior to impregnation the ovule contains an embryo sac. 2nd. That the embryo sac is commonly formed at the apex of the nucleus. 3rd. That in the interior of the embryo sac there exists a granular fluid or formative blastema. 4th. That the sac frequently protrudes beyond the exostome (ovule tube; Griffith, Dickie). 5th. That in the interior of the sac, prior to impregnation, one or more cytoblasts, or embryonic vesicles, are formed. 6th. That their formation takes place by the aggregation of molecules. (Amici, Meyen, Hofmeister.) 7th. That the cytoblasts, or embryonic vesicles, also contain a fluid more or less granular. (*Globulo-cellular cambium;* Mirbel.) 8th. That the pollen is always necessary for fertilization (apparent exception given by Smith in *Cœlobegyne ilicifolia*). 9th. That the pollen, when applied to the stigma, sends out one or more tubes (prolongations of the intine), which contain granular matter (fovilla). 10th. That in most cases the union of the pollen tube with the apex of the embryo sac constitutes the very act of impregnation. 11th. That the result of this union is the formation of an embryo. 12th. That this formation takes place either by the metamorphosis of one of the pre-existing germinal or embryonic vesicles, under the dynamic influence of the fovilla (acting catalytically?); or, as is more probable, by the union of the contents of the pollen-tube with that of a germinal vesicle, similar to what occurs in the conjugation of *Conferveæ*.

On the Importance of recognising Substances of extraneous Origin when they occur in Urine, and of distinguishing them from those Bodies which enter into the Composition of Urinary Sediments. By Lionel Beale, M.B.

In the microscopical examination of urinary deposits, the observer often meets with substances whose nature and origin cannot readily be determined. This is due in many instances to the presence of bodies which have fallen in accidentally, or which have been placed in the urine for the express purpose of deceiving the practitioner. The importance of recognising matters of an extraneous origin can scarcely be sufficiently dwelt upon, for until the eye becomes familiar with the characters of these substances, it will be obviously quite impossible to derive such information from a microscopical examination of the urine, as will enable the observer to distinguish between those substances whose presence denotes the existence of certain morbid conditions, from certain matters which have accidentally found access, and may therefore be entirely disregarded. Practitioners who use the microscope for investigating the nature of urinary deposits, will derive advantage from subjecting many of the substances referred to in the present communication to microscopical examination, by which their general appearance will soon become familiar to the observer, and he will then be able to recognise them without difficulty should they be met with in the course of an examination of urine.

As most of the undermentioned substances are readily obtained, a brief notice of their characters will be sufficient; the chief object of this communication being to direct the notice of practitioners to the fact of the frequent occurrence of many of them in urine, and to draw attention to those characters in which they resemble, or are liable to be mistaken for, any insoluble constituent of the urine. I may remark that among many substances whose presence is accidental in urine, the following are some of the most important that have fallen under my own notice:—*Human hair*, *cats' hair*, *blanket hair*, *coloured worsted*, *fibres of cotton*, *flax*, *and silk*, *small portions of feathers*, *fibres of wood swept from the floor*, *starch*, *globules of various kinds*, *fragments of potato*, *bread-crumbs*, *portions of tea-leaves*, *common house sand*, *oil globules* Once, a specimen of urine, which had been sent to Dr. Todd for examination, was found to contain several white bodies about half an inch in length, which upon microscopical examination I found to contain tracheæ, and they ultimately proved to be *larvæ of the blowfly*, although it had been stoutly affirmed that these had been passed by the patient. A few days since Dr. Stewart informed me that a man had brought some urine to him for examination with a thick bright red deposit, which was analyzed by Mr. Taylor, and proved to consist of sesquioxide of iron. The urine containing this deposit was of specific gravity 1011, and, upon the addition of ammonia, a brown flocculent precipitate (hydrated sesquioxide of iron) was thrown down. Dr. Stewart tells me that a considerable quantity of the powder remained suspended in the urine after it had stood for many hours, and that the fluid was still turbid after having been passed through a double filter. The man who brought this urine has also been endeavouring to impose upon my friend Dr. Weber, of the German Hospital.

Hair of various kinds is very frequently found amongst urinary deposits, but, as its microscopical appearance is so well known, it is not necessary to enter into a description of the characters by which it may be distinguished. The varieties of hair most commonly met with are human hair, blanket hair, and cats' hair; not unfrequently portions of coloured worsted will be found, but the colour alone will often remove any doubts with reference to the nature of the substance. Portions of human hair are sometimes liable to be mistaken for narrow casts of the uriniferous tubes —such as are quite free from epithelium or granular matter, and which present throughout a homogeneous appearance. The central canal in many cases will be sufficient to distinguish the hair from every other substance likely to be mistaken for it, but sometimes this cannot be clearly made out, and the marks on the surface may be indistinct, when attention must be directed to its refracting power, well-defined, smooth outline, and also to the sharply truncated ends, or to its dilated club-shaped extremity in the case of the hair bulb. In these points small portions of hair will be found to differ from the cast, for this latter does not refract so strongly, the lines on each side are delicate but well defined, and the ends are seldom broken so abruptly as in the case of the hair. Cats' hair can scarcely be mistaken for any urinary deposit with which I am acquainted, and its transverse markings will serve at once to distinguish it with certainty.

Cotton and flax fibres are very often found in urine. When broken off in very short pieces they may be mistaken for casts, but the flattened bands of the former, and the somewhat striated fibres of the latter, will generally be found sufficiently characteristic.

Portions of feathers are often detected in urinary deposits upon microscopical examination, and are derived, no doubt, from the bed or pillow. Their branched character will always enable the observer to recognise them with certainty.

Pieces of silk are not unfrequently present, but these can scarcely be mistaken for any substances derived from the kidney. Their smooth, glistening appearance and small diameter at once distinguish them from small portions of urinary casts, and their clear outline and regular size from shreds of mucus, &c.

Fibres of deal from the floor. Of all the extraneous matters likely to be met with in urine, and calculated to deceive the eye of the observer, none, perhaps, is more liable to be mistaken for a portion of a transparent cast, than a short piece of a single fibre of deal. In hospitals, where the floor is uncovered and frequently swept, portions of the fibres of the wood are detached, and, being light, may be very readily blown into any vessel which may be near. In fact, these fibres enter largely into the composition of the dust which is swept up. I became familiar with the appearance of these bodies for a long time before I ascertained their nature, for, although the peculiar character of coniferous wood is sufficiently well marked, when only very small portions are present, and in a situation in which they would scarcely be expected to be met with, their nature may not be so easily made out. Often only two or three pores may be seen, and not unfrequently these are less regular than usual, in which case they may be easily mistaken for a small portion of a cast with two or three cells of epithelium contained within it. I have very frequently met with these fibres amongst the deposit of various specimens of urine which have been obtained from patients in King's College hospital.

Starch granules are very commonly found in urinary deposits; usually their presence is accidental, but large quantities of starch have often been added for purposes of deception, in which case their true nature may be discovered, either by their becoming converted into a jelly-like mass on being boiled with a little water in a test tube, by their behaviour upon the addition of free iodine, or by their well defined microscopical characters. The three kinds of starch most likely to be met with in urine, are potato starch, wheat starch, or rice starch. They are readily distinguished by microscopical examination. Small portions of potato, or pieces of the cellular network, in which the starch globules are contained have been occasionally met with. Under the head of starch, may also be included bread-crumbs, which are very commonly present in urine, and have a very peculiar appearance, which may be so easily observed, that a description would appear superfluous. Many of the starch globules will be found cracked in places, but their general characters are not otherwise much altered.

Portions of tea-leaves are occasionally found in urine. The beautiful structure of the cellular portions, and the presence of minute spiral vessels, distinguish this from every other deposit of extraneous origin. A small piece of a macerated tea-leaf will be found to form a most beautiful microscopic object.

Milk is sometimes purposely added to urine, in which case there is danger of mistaking the specimen for one of the so-called chylous urine, from which, however, it may be easily distinguished by the presence of small oil-globules, with a well defined dark outline, while the fatty matter in chylous urine is in such a minute state of sub-division, that it only presents a granular appearance under the microscope.

Fatty Matter. The existence of fatty matter in urine is a subject of so much importance to the practitioner, and its accidental presence so frequent, that it may be well to consider the different forms in which it occurs, instead of simply describing the manner in which fat of accidental origin may be distinguished from oily matter, which has been excreted by the kidney. Upon the presence or absence of this deposit often depends the prognosis of a case, and hence it is of the utmost importance to recognise that form which is charateristic of fatty degeneration of the kidney with certainty.

Fatty matter occurs in urine in at least three distinct forms. The *first* form which I shall notice, is that in which it is met with in certain specimens of chylous urine, and the peculiar milky appearance of the secretion is entirely due to the existence of fatty matter in an exceedingly minute state of division. Upon microscopical examination of such a specimen, all that can be detected is a multitude of minute granular particles, not unlike those of amorphous lithates, scattered all over the field. Upon carefully focussing, it will be observed that each particle is in constant motion, and the movements resemble those met with in chyle and certain other fluids. That these particles are really composed of fatty matter in a minute state of division is shown, by the addition of ether to the urine, which immediately becomes clear; and by the evaporation of the etherial solution, the fatty matter may be obtained in its usual form. From a remarkable specimen of the so-called chylous urine, for which I am indebted to the kindness of my friend Mr. George Cubitt, I obtained as much as 13·9 grains of fatty matter from 1000 of urine; the whole of this large quantity having previously existed in the urine in the minute state of division to which I have just alluded. In such instances, it is clear that from microscopical examination alone, it would be quite impossible to determine the nature of the substance to the presence of which the peculiar character of the urine was due.

The *second* form in which fatty matter is found in urine is that of globules, each globule consisting of one portion of fatty matter, which either floats freely upon the surface of the urine, or is carried to the bottom in consequence of becoming entangled in some heavier deposit, as for instance mucus, or cells of epithelium. In this case, the oil particles will probably not be very numerous, and they are too large to give to the urine the opalescent appearance, which results from the suspension of fatty matter in a molecular state. The globules appear in the microscope as highly refractive particles, of a perfectly circular form, with a dark and well defined outline. The more minute of these globules present the appearance of a perfectly round black spot. It is in the form of distinct and *separate* globules that fatty matter is found in urine, when it finds access into that fluid accidentally, as, for instance, if a small particle of butter or a little oil fall into the urine; or if urine drawn off by an oiled catheter be subjected to examination, the oil globules will present this character, and usually they vary very much in size, some being often of considerable diameter.

The *third* form in which fatty matter is met with in urine, differs from the preceding in this essential particular, that many distinct and separate oil globules, often varying much in size, will be found collected together in the interior of a cell; at the same time, a certain number of free oil-particles may be observed. In a collection of oil particles invested with a cell-membrane, the term "fat cell" has been applied, and it is to these cells found in the deposits, and entangled in casts of the uriniferous tubes, that so much attention has been directed of late, in reference to the indications of the existence of fatty degeneration of the kidney afforded by the presence of these bodies in the urine.

Hence by carefully observing the particular character which the oily matter assumes, there is little danger of being mistaken in reference to its origin.

Infusoria and fungi.—After urine has been kept for some time, various forms of fungi, and not unfrequently some infusorial animalcules may be present—vibriones, vorticellæ, and monads are among those most commonly met with, but many other forms are frequently present. The period of time which elapses previous to the development of vibriones and fungi is found to vary very much in different cases; these bodies being sometimes found in urine within an hour after it has been passed, while in other cases the urine may be kept for many days without the development of any animal or vegetable organisms whatever.

Many other matters of extraneous origin frequently forming part of an urinary sediment might be here described, but as most of these will doubtless occur to the mind of every observer, and as their nature is often easily determined, it is unnecessary to enter into further description, which would prolong this paper to too great a length. It is hoped, however, that enough has been said to draw the attention of observers to the importance of the subject, and to point out the necessity of rendering the eye familiar with the characters of many other substances than those which really enter into the formation of *urinary* deposits, before the microscopical examination of urine can be successfully employed in clinical investigation.

TRANSLATIONS.

Description of Actinophrys Sol. By A. KÖLLIKER. From Siebold and Kölliker's Zeitsch.: i., p. 198. 1849.

(Continued from page 34.)

General Considerations.

To the above description of *Actinophrys*, it will not be out of place to add a few general reflections, and in the first place to ask what systematic position it is entitled to take.

When compared with the simplest known forms of animal life, it appears clear that *Actinophrys* is most closely allied to *Amœba* and the Rhizopoda of Dujardin, who himself agrees in this view, and considers that it differs from them only in the uncommon slowness with which the tentacles are moved. In fact *Actinophrys*, like *Amœba*, *Gromia*, &c., consists of a perfectly homogeneous, everywhere contractile substance, without any trace of structure, and having in precisely the same way processes on the surface of an ephemeral nature and of various forms. The granules also of *Actinophrys* and its clear spaces have their analogues in the granules of *Amœba* and *Gromia* and in the vacuoles of *Amœba*, *Arcella*, *Trinema*, and *Gromia*. And just in the same way an *Actinophrys* artificially divided by Eichhorn, finds its exact counterpart in an *Amœba princeps*, the same observation being made also by Dujardin. It must be confessed that, notwithstanding this correspondence, *Actinophrys* exhibits a great peculiarity in its mode of taking nourishment. But is it ascertained, it may be asked, that the Amœbæ and Rhizopoda take in their food in any other way? By no means; much rather does it seem, to the author at least, from all that is known as to the mode of feeding in those creatures, to be indicated, that it is precisely similar to that which obtains in *Actinophrys*. We have only to refer to what Dujardin remarks with respect to *Amœba* (Infus., p. 228 *et seq.*) to see that he was very near the discovery of the remarkable proceeding witnessed by the author in *Actinophrys*. Referring to the circumstance that in the first place there is in *Amœba* neither mouth nor intestine, and secondly, that, nevertheless, Naviculæ, Closteria, fragments of algæ, and other nutritious particles occur abundantly in its interior, having been admitted at any part of the surface at will—it may be held as an established fact, that the admission, digestion, and rejection of the food is effected in *Amœba* precisely in the same way as in *Actinophrys*. Dujardin, moreover, himself, although he assumes that the Amœbæ are nourished by means of absorption, and that the nutritious matters above mentioned, enter them only by accident, is not inclined to deny that they do derive nutriment from the articles thus included; adding (p. 229)—'Si toutefois on voulait prétendre, que ces corps étrangers sont entrés par une bouche, et sont logés dans des estomacs, il faudrait admettre, *que cette bouche s'est produite sur un point quelconque, et à la volonté de l'Amibe, pour se refermer et disparaître ensuite*, (this recalls Ehrenberg's expression (p. 128), that the true mouth of the *Amœba* opens only in the act of swallowing and rejection,) tandis que les estomacs eux-mêmes, dépourvus de membrane propre, se creuseraient indifféremment çà et là au gré de l'animal, pour disparaître de même; dans ce cas les mots seuls seraient différents et l'explication des phénomènes resterait encore celle, que j'ai donné.' The latter is by no means credible, and it is rather to be asserted that it is not by chance, but by will (sit venia verbo) that the food enters the body in the *Amœba*. What holds good in *Amœba* may also be supposed to be the case in the closely-allied Rhizopoda, which, although they have no vestige of a mouth, nevertheless contain Infusoria and Bacillariæ, as has been seen by Dujardin in *Arcella vulgaris* (p. 247) and *Euglypha tuberculata* (p. 251), and by Ehrenberg in *Difflugia enchelys* (p. 132) and *Arcella vulgaris* (p. 133), where even it is remarked, that the latter takes in Indigo, and that in feeding, a spot in the interior of the soft body—from time to time opens and closes—*of which spots also two are frequently present.*

Relying upon all this, the author is of opinion that *Actinophrys* belongs to the same group with *Amœba* and the Rhizopoda of Dujardin, and to which group the latter name seems most appropriate. Distinct families would be formed of the Amœbæ, the species of Actinophrys, to which probably also the genus *Acineta* would belong; and of those provided with shells, which again might be divided into those with a simple body (*Arcella*, *Difflugia*, *Gromia*, &c.) and those with a simple semi-divided body, the Polythalamia (*Miliola*, *Vorticialis*, &c.). The character of these Rhizopoda would in part be that already given by Dujardin: a structureless body of a homogeneous, contractile substance, without mouth, intestine, or other organs, with mobile processes. Reception of food at any part of the surface of the body, by a retraction of the substance and the introduction of the morsel into the interior; digestion of the aliment in spaces temporarily formed for the purpose, and expulsion of the remains at any spot at will. Propagation by fission? by germs?

Having thus shown the alliance of *Actinophrys* with *Amœba*, *Gromia*, &c., the position of the thus constituted Rhizopodous group with respect to the rest of the lower animals remains to be considered. The first question which here arises is, whether this group is to be placed with the Infusoria, or should constitute an independent class. The answer is difficult, since the structure of the Rhizopoda and Infusoria is, it must be regretted, not yet so clearly made out in all points as to admit of a certain comparison between them. The author starts with the proposition that the Infusoria (from which he excludes the Rotifera, and the Bacillaria, Volvocina, and Closterina belonging to the vegetable kingdom) all without exception consist of a *single cell.* He is of opinion that what he had shown to be the case in the *Gregarinæ*,* holds good of all the true Infusoria, as has been shown in the most convincing way by Siebold in his Comparative Anatomy. In this view all the Infusoria consist as it were of a cell, which in the one case is entirely closed (*Gregarina*, *Opalina*, *Euglena*,† &c.); and in the other possesses a mouth or even two openings. No one who examines with sufficient attention an *Opalina*, *Bursaria*, *Nassula*, &c., can longer entertain the smallest doubt as to this. He will find for the most part a contractile and structureless membrane furnished with cilia, frequently partially contractile cell-contents with granules and vacuoles, and almost always an homogeneous, frequently curiously formed nucleus.

This point being once established, it may be asked, in the second place, Can the Rhizopoda be likened to a cell? At first sight the answer would appear to be in the negative, seeing that they (*Amœba*, *Actinophrys*, &c.) have no distinct

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* That the Gregarinæ are unicellular cannot for a moment be doubted by any one who has once seen these creatures; but, on the other hand, it has hitherto been a question whether they were complete animals or not. The author thinks that this point may now be considered as settled, since his more recent observations (Mittheilung. der Züricher. naturf. Gesellschaft, heft i., 1847, p. 41, and S. and K., Zeitsch., vol. i. p. 1, et seq.), and which have been confirmed by many excellent observations by Stein (Müll. Archiv., 1848, p. 182) have shown clearly that the so-called *Pseudo navicellæ* are the germs of Gregarinæ. He would here, however, remark cursorily that the metamorphoses of the Gregarinæ into Pseudo navicellæ, apparently from their connexion in pairs, cannot be compared with a conjugation, as Stein is inclined to do, because in this connexion the contents of two Gregarinæ are not mixed together as is the case in the conjugation of the algæ, without exception, with the contents of the united cells.

† As there is scarcely any reason for doubting that Euglena properly belongs to the Monadina, and that it is a plant, it should be removed from the above category. Nor has it any distinct cell-wall, being composed wholly of a mass of protoplasm.—T.

tunic equivalent to a cell-wall, and, at least many of them, no cell-nucleus. But it must be inquired, Is this sufficient to deprive them of the title of cells? With respect to the nucleus, it really appears to be present in some of them (vid. Ehrenberg's figures), and where it is wanting, as in Actinophrys, whose nuclear and vesicular internal substance above described can here hardly be so regarded, a true nucleus may have existed at an earlier period, and be absent only in the full grown animal; or again it may be entirely wanting, and still the animal regarded as a cell. The former supposition is highly credible, the same thing taking place in many cells (human blood-corpuscle, &c.); and with respect to the latter, it may be remarked that although in the higher animals the nucleus is a constant element in the cell, it is still not proved, that, speaking generally, there cannot be a cell without a nucleus, that is to say vesicles, which otherwise in all respects as to growth, reception and rejection of nutriment, movement, increase, &c., behave exactly as do cells. It may here be stated that certain Infusoria, which on account of their great resemblance to others, distinctly unicellular, must be taken to be altogether of a like nature, nevertheless have no nucleus. With respect to the membrane, it may be regarded as certain that there are cells with a membrane of such extreme tenuity as to be hardly distinguishable from the contents; thus the author observed in blood corpuscles of the embryo chicken noticed in the act of division, that when pressure was made upon them, the two halves became separated, and without any escape of colouring matter, were again formed into perfect cells. The blood corpuscles of the Frog under pressure behave very nearly like the soft substance of the filaments of *Actinophrys*, the processes of *Amœba*, *Gromia*, &c. In the second place, it is to be remarked that there are cells, in which at a later period all difference between the membrane and the contents disappears—for instance, the elements of the smooth muscles in the higher animals—what are termed by the author fibre-cells. Which of these possible conditions, as concerns membrane and nucleus, obtains in the Rhizopoda, the author is unable to answer, not knowing with certainty whether they are to be regarded exactly in the light of cells or not, but he goes on to remark that their other relations are not opposed to the notion that they may be simple cells; such as their structureless homogeneous contents, its contractility, and the vacuoles in it, resembling in all respects the contents of the body in the unicellular Infusoria; then the simplicity of their form and mode of taking food, so closely resembling the way in which the Infusoria introduce a morsel into their parenchyma and there digest it. Certainly the presence of a cell-membrane is scarcely reconcilable with the circumstance that the body is capable of admitting a morsel of food at any part of the surface, but partly, it is not indispensably necessary to assume that such exists in the fully developed Actinophrys, and partly also it is by no means wonderful that a membrane, in consistence almost the same as the rest of the parenchyma, should be capable of being torn and of reuniting. To leave, however, this region of hypotheses and possibilities, it may at all events be stated that the notion that the Rhizopoda are of a nature similar to simple although modified cells, has especially this to recommend it, that there is little else to be made of them. It cannot be admitted that they consist of a whole aggregation of cells, and as little is it to be supposed that they are simply a mass of animal matter without further distinction, as it were, an independent living cell contents. And the less can this supposition be entertained, because, according to all recent investigations which have proved cells to be the elementary parts of the higher animals and plants,—as the initial point for further development (ova, spores, &c.), as the simplest form of vegetable organisms (Closterium, Navicula, unicellular Algæ, &c.), we cannot in the animal kingdom also, but regard the unicellular animal as the simplest form. On this account it seems provisionally, best to consider the Rhizopoda as peculiarly modified simple cells—which probably may have a membrane, but in the mature condition at least, to all appearance have no nucleus, and to arrange them together with the other Infusoria in the class of Unicellular animals.

In conclusion, the author adds a few words respecting the contractile substance of *Actinophrys* and the Rhizopoda in general. He is induced the more to do this by a very interesting Memoir by A. Ecker, 'On the Structure and Life of the Contractile Substance of the lowest Animals.'* The contractile substance presented in the Rhizopoda is evidently very nearly allied, physiologically and chemically, as well as in external appearance, to that which Ecker describes in Hydra, and has shown to exist also in other animals, and from the author's observations on those animals he cannot but confirm Ecker's statement. This contractile substance, termed by Ecker 'amorphous' (an improved edition of Dujardin's Sarcode), deserves in every case to be further investigated in the way pointed out by Ecker, and to be compared with the contractile elements in the higher animals. Already, as it

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* S. and K., Zeitsch., B. i. p. 218.

seems to the author, is an interesting law apparent when all contractile parts are regarded, that only two such occur in the animal kingdom,– Cell-membrane and Cell-contents, which either by themselves alone or together constitute a contractile element. Other parts, such as the cell-nucleus and its derivatives—nucleated fibres, and elastic fibre—amorphous substance not deposited in cells—coagulated fibrine, &c., are never contractile.

1. Contractile cell-membranes occur:

a. In unicellular animals. 1. As universally contractile membranes, such as are met with in *Gregarina*, *Leucophrys*, *Coleps*, *Trachelius*, *Loxodes*, *Bursaria*, *Kolpoda*, *Uroleptus*, and many other infusoria. 2. As motile processes of a contractile or motionless membrane (*Opalina*, *Bursaria*, &c.).

b. In aggregated simple cells. 1. As in membranes contractile *in toto*, as in the heart-cells of the embryo in *Alytes* and *Sepia*, the cells of the embryo *Planaria*, and those in the tail of the larvæ in the Tunicata (Ann. d. Sc. Nat. 1846, p. 221), and the caudal vesicle of the Limax embryo (*Ecker*, l. c.).

2. As partially contractile membranes, cilia, or epithelium cells.

c. In cells which are united so as to form a tube, capillary lymph, and blood-vessels.*

Contractile cell-contents occur:

a. In unicellular animals. In all infusoria in which there are contractile spaces, a part at least of the contents or parenchyma is contractile.

b. In non-independent cells. The spermatic filaments of animals which are here meant, originate as a deposit in the interior of cells, or, more correctly, in the nucleus of the spermatic cells.

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* That the structureless walls of these canals are of the nature of coalescent cell membrane was shown by the author in the 'Ann. d. Sc. Nat., 1846.' It is true that Bidder ('Verhältniss d. Ganglien-Körper zu den Nervenfasern,' 1847, p. 53) has recently termed the Author's statements merely conjectures, although, as it would appear, simply upon the ground that they do not accord with his own real conjectures (l. c. p. 54). He adduces *no facts* contradictory to the Author's statements, and relies solely upon the law propounded by Reichert, and adopted by no one but himself, and which is altogether incorrect—viz. that elementary forms of different histological importance never enter a continuous connexion with each other.

This is not the place to remark farther upon this question, and the author contents himself with observing, without meaning anything personal, at least this much, that those who upon actual examination of the capillaries of the Batrachian larva do not see that they are formed from outstarting processes and stellate cells, have not claim to the title of microscopist.

c. In tubes formed out of coalesced cells. Under this head are to be reckoned the animal or striped muscular fasciculus, in which the contents are represented by the primitive fibrillæ, and the tubes formed out of coalescent cells by the Sarcolemma.*

2. Contractile membranes and contractile cell-contents, united into one body are seen :—

(*a*). In unicellular animals; premising that *Actinophrys* and the Rhizopoda come under this head.

(*b*). In multicellular animals; in which all the cells have coalesced to form a homogeneous substance. Under this head are to be reckoned :—

1. The Hydræ. These, according to Ecker's investigations, exhibit no trace of cells—nothing, in fact, but a uniform substance;—they must, therefore, at least according to the author's view, be regarded as originally composed of a mass of cells, since we know that they are developed from ova, which have undergone the process of segmentation.

2. The parasite of the venous appendages of the Cephalo-

Bidder also allows no weight to the Author's observations on the development of the muscular fasciculus (l. c., p. 50), relying upon the untenable law of continuity sought to be established by Reichert, and on the observations of Holst and Reichert ('De Structurâ Musculorum,' Dorpat, 1846). The Author, however, maintains his own opinion as the only true one, in opposition to the Dorpat observers. Renewed investigations have shown him that, in the chicken, in the mammalian embryo, and in the Batrachian larva, in all alike, the whole muscular fasciculi originate in series of cells, and that each of the widely separated fibrillæ originates in a series of cells, and that they are simply modified cell-contents. This has been recently confirmed also by Bendz, in the Vertebrata, and Leydig, in the Annelida. With respect to the striped muscles, it is not uninteresting to notice the occurrence in them of anastomoses, or branchings of the entire fasciculus. This may be observed in the fasciculi of the auricle of the frog (fig. 6). In this case it will be found that here and there two fasciculi are united by a transverse fasciculus, and that there exists not merely a mutual application of separate fasciculi, but a continuous connexion, an actual coalescence. The Sarcolemma of the three fasciculi in fig. 6, for instance, forms three connected anastomosing tubes, and the primitive fibrillæ also pass apparently without any line of demarcation from the one into the other, although it cannot be exactly said that they are actually continuous in the three fasciculi. In the same way Dr. Leydig has noticed very beautiful anastomoses and branchings of the striped muscles in *Piscicola* (S. and K., Zeitsch., B. i. p. 108). The author has no doubt but that these anastomosing striped muscles, in part at least, originate in stellate cells; in this case there exists a perfect analogy in the development of the most important higher elementary tissues, inasmuch as that they are all formed, in part by the coalescence of rounded or elongated, and in part by the union, of stellate cells. The latter condition has hitherto been observed in the capillary blood- and lymph- vessels in the terminations of the nerves (S. and K., Zeitsch, B. i., p. 54) and in those of the tracheæ in insects.

poda, which the author has named *Dicyema paradoxum*, in which exactly the same condition is found to exist as in Hydra (vid. Kölliker's Bericht üb. d. Zootom. Anst. in Würzburg, 1849, p. 61).

(*c*.) Certain cells elongated into fibres in the higher animals —for instance, the so termed muscular fibre-cells or the elements of unstriped muscle; which are to be regarded as elongated cells, in which the membrane and contents are united into a soft substance.

In this enumeration, all those parts of animals which have been distinctly proved to possess a contractile property are contained, and it is consequently apparent that all these parts, taken in a general point of view, fall into but few categories—viz. into two, contractile cell-membranes and motile cell-contents. It is not thence, however, to be inferred that there are but two kinds of contractile elementary tissue, much rather must several such, more or less different, be admitted according as the cell-membrane and its contents assume one form or another.

Such an arrangement as the following appears to be most suitable:—

Contractile elementary tissues are—

1. The amorphous contractile substance = *a*) a cell-contents; *b*) one or several cells with membrane and contents united.

2. The spermatic filaments = the formed nuclear contents of a cell.

3. The cilium = an out-growth of a cell-membrane.

4. The contractile vesicle = an entire cell-membrane.

5. The contractile tube = a number of coalescent cell-membranes.

6. The contractile fibre-cell = an elongated cell with membrane and contents united.

7. The contractile fibril-fasciculus (animal muscular fasciculus) = the contents of a series of coalescent cells, which are metamorphosed into a homogeneous contractile tube (vid. Leydig on 'Piscicola').

If instead of the anatomical characters, the physiological properties of the contractile parts are regarded, other groupings of them naturally arise; thus, for instance, 1, 2, 3, and in which the movement is wholly independent of nerves, and 5, 6, 7, in which it is effected by nervous influence, would respectively be associated. Besides this, regard must be paid to the relations of the contractile element, to galvanism, cold, mechanical irritation, &c. This is a point, however, which cannot be further entered upon in this place, and the author concludes with the expression of a wish that his readers may deduce at least this, from his communication, that what is simple enough in nature affords a key to what is compound, and is therefore worthy of all consideration.

On the Microscopical and Chemical Examination of the Mantle of certain ASCIDIANS. By DR. H. SCHACHT. Müller's Archiv, p. 176. 1841.

(Continued from page 29.)

The above facts show, first of all, two things:—1. That the cell-membrane in the mantle of *Phallusia* does not, as stated by Kölliker and Löwig, consist of cellulose, but rather that it behaves towards iodine and sulphuric acid, as well as towards caustic potass, exactly like an animal substance nitrogenous; 2. That the homogeneous, or only in the second layer, slightly fibrous interstitial substance, is composed of tolerably pure cellulose.

In *Clavellina* Kölliker and Löwig found cells in a lamina of the mantle, similar to those in *Phallusia*, also imbedded in an interstitial substance; in the tunic of *Salpa* these cells are wanting, the cellulose substance contains nuclei and crystals; in *Pyrosoma*, they found in the structureless tunic, only isolated ramified cells; the structureless membrane of *Diazona* is penetrated according to them by elongations of the fleshy tunic of the animal. In the tunic of *Didemnum*, the same observers again found cells, of which the membrane, though incrusted with carbonate of lime, was soluble in boiling potass; in *Aplidium* they found similar cells in the interstitial substance, and here also the membrane of the cells was soluble in the caustic potass—only the interstitial substance remaining. In *Botryllus*, according to them, the internal layer consists of delicate fibres, which, like the rest of the homogeneous substance, in which nuclei and crystals occur, resist the action of hydrochloric acid and of potass; the nuclei are soluble in potass; the crystals insoluble in acid; branched channels, dilated at the extremity, which exist in this instance, are regarded by Kölliker and Löwig as processes of the fleshy tunic.

[The author then details his experiments on the mantle of *Cynthia microcosmus*, and proves the existence of cellulose in it in a fibrous form, mixed with another substance soluble in caustic potass, of which the outer epidermis appears to be wholly composed. But whether the fibres are composed of pure cellulose, and the second nitrogenous element is simply deposited between them, or whether the latter also pervades the substance of the fibres themselves, he is unable to determine. The cellulose, however, in *Cynthia microcosmus* appears to differ in some respects from that in the tunic of *Phallusia mamillaris*, inasmuch as it is coloured blue by ioduretted chloride of zinc, which the latter is not.

In this part of his paper the author describes a mode of procuring thin slices of very soft or yielding substances, by including the latter tightly between two pieces of cork and cutting thin slices of the whole with a razor. The structure of the mantle in the undescribed Ascidian from Chili appears to be very similar to that of the Cynthia last described.] He then proceeds :—

Although the methods pursued by us respectively, were very different, yet the results of my observations coincide in great measure with those of Kölliker and Löwig. In only one principal point do I differ from them : the membrane of the large cells in the mantle of Phallusia *is not composed of cellulose.* It behaves exactly like animal membrane, and is probably nitrogenous, and would therefore represent the primordial sac of the vegetable cell, which exhibits precisely the same chemical re-actions.

It seems to me that the observers just quoted had not seen the membrane of these cells, indicated by the delicate folds described above, as they adduce as a distinction between these cells and those of a plant, the coalescence of their walls, composed of cellulose, with the homogeneous interstitial substance. In *Didemnum candidum*, it is true, they observed not only the membrane, but also that it was soluble in caustic potass; and consequently in this case it could not be composed of cellulose. That I did not meet with isolated cells in the mantle of *Cynthia* as Kölliker and Löwig did, does not surprise me, those observers not having found a trace of such cells in the mantle of *Phallusia gelatinosa*, whilst in another specimen they noticed nuclei and indications of these cells. It seems, therefore, as if the latter belonged to a definite period of the animal's life.

Kölliker and Löwig at the end of their paper refer to the history of the development of the embryo of certain Ascidians, given by Milne Edwards; from which they conclude :—

1. That the external structureless tunic of the embryo afterwards forms the mantle of the adult animal, consisting of cellulose; 2. That this tunic, which subsequently contains nuclei, fibres, &c., is the product of the cells formed by the segmentation of the yelk. They believe also that the mantle of other Ascidians, which is perforated by vessels, as in *Phallusia*,

is at first structureless, and in this condition is not composed of cellulose, but that cells are formed in its substance which multiply and secrete the cellulose; at a latter period, however, themselves again disappearing. They also detected in the stomach and intestines of *Phallusia*, *Clavellina*, and *Diazona*, both the remains of Algæ as well as Closteria [in salt water?]. The cellulose, therefore, would seem to be introduced from without; in what way, however, it is separated from the blood, in order to be secreted in certain parts of the body, remains unexplained; an accurate analysis, therefore, of the blood of the Ascidians would be of great importance.

If, now, the occurrence of cellulose in the mantle of the Ascidians above described, be compared with the conditions under which the same element exists in the vegetable kingdom, the following very essential differences are apparent:—

1. In the vegetable kingdom the cellulose constitutes the so-called primary cell-membrane, and the thickening layers of the cell deposited upon it. The vegetable cell-wall, consisting of cellulose, is always separated from the wall of the neighbouring cells, by an interstitial substance (intercellular substance) which is soluble in chlorate of potass and nitric acid. On their being boiled, therefore, with caustic potass and by maceration [in chlorate of potass and nitric acid] these cells separate from each other; but in the mantle of *Phallusia* no such separation takes place, because there, the cellulose, although probably distinct from the nitrogenous membrane of the cells, itself constitutes the interstitial substance; the intercellular substance of the plant being entirely absent.

2. The vegetable cell is thickened by the laminated deposit of new cellulose in the previously existing layers of that substance; such a laminated structure, which is demonstrable by proper treatment in all thickened vegetable cells, is altogether absent in the cellulose of the mantle of the Ascidians.

3. In the vegetable kingdom the cellulose never occurs in the form of free fibres, as in the mantle of *Cynthia*, &c.; the band in the spiral vessels of plants, apparently composed of a fibre, arises in the unequal development of the thickening layers.

4. In the vegetable kingdom, the cellulose never appears as a homogeneous substance, either between the cells or nuclei of cells; as is the case in the mantle of the Ascidians.

These differences in the mode of occurrence of the cellulose are so essential, that it would seem to be impossible to confound an animal tissue containing cellulose with any vegetable tissue whatever. [The appearances exhibited in a section of the stem of *Laminaria saccharina*, when treated with iodine and sulphuric acid, are adduced and figured by the author, as a contrast to what takes place under the same re-agents in the mantle of *Phallusia*.]

The chemical relation of the cellulose itself, however, in the Ascidians examined by me, is not essentially different from vegetable cellulose. Caustic potass has no effect upon either; sulphuric acid dissolves both; iodine and sulphuric acid colour both equally, blue; ioduretted chloride of zinc induces, it is true, in most vegetable tissues the same blue colour as that produced by iodine and sulphuric acid; there are, on the other hand, vegetable tissues (such as, in *Fucus serratus*, *Chordaria scorpioides*, the wood-cells of *Pinus sylvestris*, &c.) upon which the same re-agents produce no effect; the ioduretted chloride of zinc appears generally to be less energetic in its action than sulphuric acid. After they have been boiled with caustic potass both the cellulose-substance of the mantle of the Ascidians and the thickening substance of the so-termed plant-cell are coloured blue or violet by the ioduretted chloride of zinc solution, the potass probably in both cases removing a material which prevented the action of the re-agent.

By maceration after Schultz's method, the last-mentioned material, in the Ascidians above noticed, is as little dissolved as the cell-membrane in *Phallusia*, nor is it, in the vegetable kingdom, always removed by the same maceration; the thickening layers of the epidermis cells of several plants are not coloured blue by ioduretted chloride of zinc after maceration, whilst after boiling with potass that re-agent produces the characteristic colour. The substance, therefore, in the mantle of the Ascidians, soluble in caustic potass, appears to be closely allied in its properties to the so-termed incrusting substance of the vegetable tissue.

In the mantle of *Phallusia*, we have, as I have certainly proved, both a homogeneous, interstitial substance composed of cellulose, and also indications of fibres composed of the same element; besides which there are, in the interstitial substance and between the fibres, nuclei and cells, thus the same elements as those which occur in *Cynthia* and the new species from Chili; in the case of the *Phallusia* the cells are more abundant, in the latter the nuclei and fibres; which seem generally to accompany each other. In the fibrous part of the mantle of *Phallusia* we find only nuclei, and no cells; in the portion, again, which consists of cells, no fibres, and but few nuclei. As in this case we are without any history of the development of the tissue, no further conclusions can be drawn respecting it.

Although, in the present state of science, the occurrence of cellulose does not suffice for a distinction between plants and animals, yet the previously established law that the animal cell-membrane always contains nitrogen retains its force. The animal cell is in all cases, as far as I know, entirely different from the vegetable cell. The intercellular substance is always wanting in tissues composed of animal cells; the animal cell itself corresponds with the primordial sac of the plant-cell, which also does not consist of cellulose, but is probably nitrogenous, like the animal cell-membrane. Whilst the plant-cell is thickened by the secretion of cellulose around the primordial sac, and thus obtains the true cell-wall; the animal cell also secretes a material—in the mantle of the Ascidians the same cellulose—but this material does not form a special envelope around the previously existing nitrogenous cell, the secretions of the individual cells, owing to the absence of any intercellular material, coalescing into one substance. In this way probably is formed the interstitial substance composed of cellulose in the mantle of *Phallusia;* and in like manner the stroma of the cartilaginous tissue, which is not composed of cellulose, and the interstitial substance, impregnated with calcareous salts of the osseous tissue. The want, therefore, of an intercellular substance constitutes the principal distinction between the animal and vegetable cellular tissues. Owing to this, the animal cells, even in cases where cellulose occurs, never have a wall composed of that substance, which is characteristic of the vegetable cell. It is to be regretted that this diagnostic character is wanting in the lowest unicellular animals and plants.

The existence of the intercellular substance has, it is true, been very recently disputed, with respect to the plant-cell, by Wigand (Intercellular Substance and Cuticula. Braunschw. 1850). That author has termed the true intercellular substance, which, so far as my most recent investigations extend, is always present, the primary cell-membrane, whilst the latter is not to be distinguished, either optically or chemically, from the thickening layers of the vegetable cells consisting of cellulose.

The *resumé* of my reseaches therefore may be thus given:—

1. In the mantle of the Ascidians there is a substance insoluble in caustic potass, but soluble in sulphuric acid, which is turned a beautiful blue by iodine and sulphuric acid, and which consequently consists entirely of cellulose. This substance constitutes the interstitial substance of the cells; in the mantle of *Phallusia* it is homogeneous, but in *Cynthia*, &c., exists for the most part in a fibrous form.

2. The mantle of the Ascidians contains, besides this cellulose, another material soluble in caustic potass, but insoluble

in sulphuric acid, and not coloured blue by iodine and sulphuric acid, and which consequently is not cellulose; in the mantle of *Phallusia* it is only sparingly present, but in *Cynthia* and the new Chilian Ascidian it is much more abundant, and alone constitutes the corneous epidermis of their mantle.

3. The membrane of the cells in the mantle of *Phallusia* does not consist of cellulose; it is coloured brown by iodine and sulphuric acid; is soluble in caustic potass, and behaves exactly like an animal membrane, as do the nuclei and vessels.

4. In the mantle of Phallusia cells abound in a homogeneous, interstitial substance composed of cellulose; it is only at the inner margin of the mantle that fibres composed of cellulose, with nuclei amongst them, make their appearance. In Cynthia, &c., there are scarcely any traces of cells, whilst the *nuclei* and *cellulose fibres* abound.

5. A tesselated epithelinm, containing no cellulose, covers the inner surface of the mantle of the three Ascidians examined by me; the outer surface of the mantle of *Phallusia* appears to possess a similar epithelium.

6. There are two essential points of difference between the modes in which cellulose occurs in the Ascidians and in the vegetable kingdom—1. In *Phallusia* the cellulose constitutes the intercellular substance, but does not, as in plants, form an integral part of the cell-wall itself; 2. In *Cynthia* and other species the cellulose forms free fibres, a form in which it is never observed in the vegetable kingdom.

7. The substance of the mantle in the Ascidians is not disintegrated by boiling with caustic potass or by maceration with chlorate of potass and nitric acid, like the vegetable cellular tissue into its elementary parts; there is in it none of the intercellular substance universally present in vegetable tissues, and by which the cells are connected, but which intercellular material is never composed of cellulose, as it resists sulphuric acid, but is soluble in caustic potass, as well as by maceration.

On UNICELLULAR PLANTS *and* ANIMALS. By C. TH. v. SIEBOLD. From Siebold and Kölliker's Zeitsch. f. w. Zool. Bd. 1, p. 270.

IN the first part of my work on the 'Comparative Anatomy of the Invertebrata,' published in 1845, I have arranged the Protozoa (*Infusoria* and *Rhizopoda*) as unicellular animals; thus separating them from a series of minute organisms, described by Ehrenberg as Polygastric Infusoria, viz. the Closterina, Bacillaria, and Volvocina, which I referred to the vegetable kingdom. The limits of that work did not allow me to adduce more than the most important reasons by which I had been induced to come to this conclusion. I could well foresee that in the publication of these views I should be placed in direct opposition to Ehrenberg's authority; an authority so generally recognised. Ehrenberg had already reproachfully said that I should have been more careful in protecting science against new opinions respecting the organization of microscopic organisms, which are easily introduced, but not so readily dissipated. I can assert, however, that having for years entertained doubts as to the correctness of Ehrenberg's views as to the organization of the lowest animals, I have not ventured to oppose so great an authority, unless prepared by the assiduous study of the lower organisms, and that the deeper did I enter into this inquiry the deeper did my doubts, with respect to Ehrenberg's views, become rooted.

How very much disinclined I have been from the first to disseminate lightly and incautiously, erroneous views in science, is shown by the way in which I acted with respect to an error I had fallen into, in the year 1836, and with which I was charged by Ehrenberg in 1848, meaning me, when he says, without mentioning my name, "the author of the new genus of an inch-long double animal (*Syngamus trachealis*), which, after the publication of his correct anatomy of it, it was necessary for some one else to remark is nothing but a pair of strongyli in the act of conjunction, as he himself acknowledges."—Wiegmann's *Archiv*, 1837. This error, the moment I knew it, I recanted; so that it was not quite a year before the scientific world. On the other hand, how obstinately does not Ehrenberg adhere to the chain of delusions and errors in which he has more and more closely involved himself from year to year. In vain, hitherto, have other naturalists in Germany, on the Seine, and on the other side of the Channel, endeavoured to draw either Ehrenberg or his followers from their erroneous ways, and to set them on the right path; and I will therefore direct the attention of the latter to a voice, which, even from the other side of the Alps, has made itself loudly heard in opposition. Meneghini, of Pavia, seeking to prove the vegetable nature of the Closteria and Desmidiaceæ, thus expresses himself on the subject of Ehrenberg's errors:—"Cosa se ne deve dedurre? Che anche il più accurato osservatore e l' uomo de genio possono errare. Nè ciò potrà mai scemarne il merito, o rendere men importanti i benefizii ch' egli rese alla scienza. Il danno non ridonderebbe che su coloro, i quali, schivi alla fatica dell' osservare, si accontentano della autorità del maestro et ne abbraciano indifferentemente, così le vere scoperte come gli errori. Grazie al cielo l' epoca del autorità e tramontata, e chi vè si aggioga erri pure conpace, che per questo la scienza non avanzerà meno, ed anzi da quegli errori stessi essa potrà trarre vantaggio."*

With respect to my views on the organization of the Protozoa, published in 1845, I have nothing in the main to recall; on the contrary, I have since then had the satisfaction of knowing that recognised naturalists and distinguished microscopists have already sided with me.

It is, moreover, highly gratifying to notice that at present the study of the lower vegetable forms, which as unicellular plants correspond to the Protozoa as unicellular animals, is exciting a very high interest, and that these hitherto much neglected organisms are now finding investigators among the most eminent Botanists, by whose labours their position in the vegetable world will eventually be decided.

As one of the most important of the works that have appeared of late upon this subject, the following must be indicated:—Nägeli's 'Genera of Unicellular Algæ, physiologically and systematically considered.'†

I believe it will not be without interest if I here notice the more important points in which, according to Nägeli's researches, the unicellular Algæ are distinguished from the lower animal forms. As especially worth consideration, I would adduce the following expression of Nägeli's (p. 2):—"It is to be lamented that of several genera and of many species of hitherto known unicellular Algæ nothing has been observed respecting their propagation, and that consequently not only has their systematic position but even their independence as unicellular plants remained in doubt." I am satisfied that many of Ehrenberg's Infusoria, were their origin and development, as well as their modes of propagation, fully traced, would long since have been recognised as vegetable forms; that is to say, as lower forms of Algæ.

For the better appreciation of the exposition given by Nägeli respecting the organization and vital actions in the unicellular Algæ, with reference to the vegetable forms considered as Infusoria by Ehrenberg, it will be necessary to premise a list of those vegetable organisms which have been treated by Ehrenberg as Infusoria, and by Nägeli as uni-

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* G. Meneghini. Sulla animalità delle Diatomee. Venezia, 1846, p. 172.

† Gattungen einzelliger Algen physiologisch und systematisch bearbeitet von C. Nägeli (Zurich, 1849, mit 8. lith Tafl.).

cellular Algæ. Among the eight orders of unicellular plants instituted by Nägeli, that of the CHROOCOCCACEÆ contains, in Meyer's genus Merismopœdia, *Gonium glaucum*, *tranquillum* and *punctatum*, Ehr. The order of the DIATOMACEÆ corresponds to the siliceous Bacillaria, Naviculacea, Echinellea, and Lacernata, Ehr. In Nägeli's order of the PALMELLACEÆ we find *Arthrodesmus* and *Tassarthra*, Ehr., referred to *Scenodesmus*, Mey., as well as the genus *Micrasterias*, Ehr., to *Pediastrum*, Kütz. Lastly, the order DESMIDIACEÆ contains many unicellular Algæ, placed by Ehrenberg under the genera *Desmidium*, *Pentasterias*, *Euastrum*, and *Closterium*. For part of these Ehrenberg's definition is retained; but others of them are raised to the rank of distinct genera. Thus has Nägeli from *Closterium trabecula*, Ehr., formed the genus *Pleurotœnium*, and from *Closterium cylindrus*, Ehr., the genus *Dysphinctium;* whilst a portion of the Desmideæ with *Pentasterias* have been placed under the genus *Phycastrum*, Kütz.

According to Nägeli (p. 3), the unicellular Algæ occur either solitary or united into colonies, which readily break up into single cells; or they may be firmly united by a gelatinous envelope, though separated from each other by a gelatinous substance, and without any organic connexion; or they are placed singly at the extremities of a branched gelatiniform peduncle. Occasionally, also, the cells are firmly connected into a parenchyma, as in multicellular plants, in which case the connexion breaks up into smaller portions, or even into single cells, either not at all or but very seldom.

With regard to the relation of the unicellular Algæ to the unicellular animals, and the unicellular condition of multicellular animals, Nägeli (p. 4) thus expresses himself. "The most important difference:—that the vegetable cell-membrane contains no azote, whilst the animal cell-membrane does—cannot be applied, especially in doubtful cases; the tenuity of the membrane not allowing of the investigation. That animals possess the power of locomotion but plants not, is, in the first place, incorrect, as applied generally, and also here the less admits of application, because many unicellular Algæ exhibit motion, frequently very energetic motion (when swarming), whilst the ova of multicellular animals are quiescent. The unicellular Algæ differ from the Infusoria in this, that their membrane and its appendages are not motile, and that consequently they have a rigid form, whilst the latter, in some instances, change their figure, and in others are furnished with motile-cilia. The presence of starch in the cell-contents is, further, invariably decisive as to the vegetable nature of a cell. The ova of multicellular animals, the figure of which is rigid and unchangeable, may also be recognised as not belonging to the unicellular Algæ from the want of colouring matter, which is present in all the latter." I shall have an opportunity further on of recurring to several of these points, and of entering more particularly into them.

As respects the chemical relation of the cell-contents of unicellular Algæ, Nägeli lays great stress upon the presence of colouring matter. This colouring matter is distinguished by him as *Chlorophyll*, *Phycochrom*, *Erythrophyll*, and *Diatomin*. The Chlorophyll is of a grass or yellow-green colour, little or at all affected by diluted acids and alkalies, and frequently turns brownish-green upon the death of the plant.* The Phycochrom is verdigris-green or orange, changed into orange by the action of diluted acid, and into a brown-yellow by that of diluted alkalies. The Erythrophyll presents a red or purple colour, not changed by diluted acids, but becoming green on the addition of alkalies, and also most usually after death. The Diatomin is brownish-yellow, not altered by diluted alkalies, but changed into verdigris-green by diluted hydrochloric acid, and, for the most part, by death. Together with the colouring matter, continues Nägeli (p. 9), starch grains, or colourless oil-drops, are frequently formed, with the increase of which in the persistent cells (dauerzellen) the former finally disappears.

I must here remark, that we can scarcely expect chemistry to decide what is animal and what plant, having several times been deceived in our hopes in this respect. The non-nitrogenous cellulose, which at first sight appears to be an exclusive attribute of the vegetable, also occurs pretty generally disseminated in the animal kingdom, as we learn from the researches of C. Schmidt on *Cynthia mamillaris*, and those of Kölliker and Löwig on a great number of the most various of the lower animals. Just as little does Chlorophyll appear to be exclusively characteristic of the vegetable world, since the green granules and vesicles, which occur imbedded in the parenchyma of *Hydra viridis*, of various Turbellariæ (*Hypostomum viride* and *Typhloplana viridata*, Schm.), and of Infusoria (*Euglena viridis*, *Stentor polymorphus*, *Bursaria vernalis*, *Luxodes bursaria*, &c.), are probably closely allied to Chlorophyll, if not identical with it. Erythrophyll also might be said to occur in the lower animals, for instance, in *Leucophrys sanguinea* and *Astasia hæmatodes*, in which latter the red colour frequently passes into green, as does the Erythrophyll of unicellular Algæ.

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* *Vide* Cohn.

Another more important circumstance connected with the chemical composition of the cell contents, is also noticed by Nägeli, and which relates to the so called red eye-spot of certain Infusoria. He saw, for instance (p. 9), in the midst of the Chlorophyll of certain unicellular Algæ, one or several bright red or orange-coloured oil-drops, upon which he remarks upon the similarity of these red granules with the red point, which occurs in several swarm-spores, for instance in Ulothrix. An inspection of Nägeli's Pl. IV., B. fig. 1-4, will at once show the identity of the bright red oil-drops in the quadrangular unicellular Algæ *Polyedrium trigonum*, *tetragonum*, *tetraedricum*, and *lobulatum*, Näg., as well as in the interesting new unicellular Algæ, *Ophiocytium majus*, Näg. (Pl. IV., A. fig. 2), with the points, so often stated to be eyes by Ehrenberg. These are precisely the same red points, as those which are met with also in *Eudorina*, *Chlamidomonas*, and *Volvox* Infusoria—which I must declare to be unicellular Algæ. Very remarkable is Nägeli's statement (p. 9), that the chlorophyll in many unicellular Algæ occasionally disappears altogether, being transformed into a red or orange-coloured oil, a change not always connected with the death of the cells, as for instance in *Pleurococcus miniatus*, Näg.; *Protococcus nivalis*, Kütz.; *Palmella miniata*, Leibl., &c.

In almost all the genera in which chlorophyll occurs Nägeli found (p. 11) one or more *chlorophyll-cells*, for the most part in regular number and disposition, and exhibiting the appearance of granules or even of nuclei. Nägeli satisfied himself that these chlorophyll-cells, even from external appearance, are the same forms as those which occur in the multicellular algæ containing chlorophyll, such as *Zygnema*, *Spirogyra*, *Spheroplea*, *Conferva*, &c. Further investigation perfectly assured him of their identity. These chlorophyll-cells at first contained only chlorophyll (that is, mucus coloured by chlorophyll) with a delicate membrane. But they seldom remain in this condition, starch at a subsequent period becoming developed in them, by which the chlorophyll is wholly or in part displaced. Then there either lie in the chlorophyll-cell one or several minute starch-grains, or it becomes almost entirely filled with starch, as happens in the Palmellaceæ and Desmidiaceæ. From this it follows that, although the presence of starch, as Nägeli says, is decisive as to the vegetable nature of a cell, this important means of diagnosis does not always admit of application, because starch is not found in all stages of the development of those plants which might be confounded with unicellular animals.

But to return to these chlorophyll-cells—is it not apparent that they are the bodies described by Ehrenberg as the testes? To perceive this it is only necessary to compare the various figures in Nägeli's work with Plates X. and XI. of Ehrenberg's great work, in which *Scenodesmus*, Mey., is figured as Arthrodesmus and Tassarthra, and further *Pediastrum*, Kütz., as *Micrasterias*. The colourless hollow spaces filled with water, observed by Nägeli (p. 91, 95, &c.) in the above named, as well as in many other unicellular Algæ, have been regarded as gastric cells by Ehrenberg, as is obvious at the first glance, whilst the green granular Chlorophyll contents of these vegetable organisms, according to Ehrenberg, would have to be regarded as ova. In various Desmidiaceæ, for instance in *Pleurotœnium*, *Calocylindrus*, and *Closterium*, Nägeli noticed several Chlorophyll-cells, frequently arranged in a serial manner. In *Closterium digitus* and *Moniliferum*, as well as in some other Closteria, he observed in the centre of the cell a clear nuclear-vesicle with an opaque central nucleolus. It is these chlorophyll and nuclear cells which Ehrenberg and Eckhardt would arbitrarily explain sometimes as a polygastric apparatus, sometimes as the male glandular organs of the Closteria.

The cell-wall in the unicellular Algæ, according to Nägeli (p. 12), exhibits in respect to colour, conformation, and substance, the greatest variety. Very frequently it possesses a considerable thickness, and in this case may be regarded as laminated, the innermost very delicate layer representing the true cell-membrane, whilst the external thick layer, more or less distinctly defined on the outer side, constitutes an envelope for the cell. This enveloping membrane consists of vegetable gelatine in various stages of condensation. It may surround each individual cell, or contain 2, 4, 8, &c. together, or even a whole aggregation of cells, as an entire family or colony. As forms of Algæ furnished with a gelatinous envelope I may adduce *Gonium*, *Schizonema*, *Naunema*, and *Syncyclia*, Ehr.; to which must be added *Eudorina*, *Sphærosyra*, *Chlamidomonas*, *Pandorina*, and *Volvox*, Ehr. In some cases the lamination and thickening of the envelope takes place only on one side, whence it assumes the form of a peduncle, at the extremity of which the cell is placed, owing to which, when longitudinal scission of the cells takes place, a branched peduncle is produced. With reference to this compare the figures of *Synedra*, *Achnanthes*, *Echinella*, *Cocconema*, and *Gomphonema*, Ehr. Frequently also the cell-membrane exhibits thickenings, which are sometimes placed towards the interior (in the Diatomaceæ), sometimes towards the exterior (in *Euastrum* and *Closterium*).

The growth of the unicellular Algæ, according to Nägeli, takes place, either with a general expansion of the cell-membrane or with a unilateral, or point-growth as it is termed. The propagation of the unicellular Algæ (p. 17) is effected in very various ways, by division, by conjugation, by free cell-formation, and by abscission of segments, with various modifications. Of these various modes of propagation discussed by Nägeli, I will only observe upon those which have reference to the Algæ described by Ehrenberg as Infusoria.

In the mode of propagation by scission the entire cell-contents, according to Nägeli, become individualised into two (rarely four) parts. After the formation of these filial cells the mother-cell ceases to exist. Nägeli here adduces, as an example, the propagation of the Palmellaceæ (to which belong several species of *Gonium*, Ehr.), the Diatomaceæ and Desmidiaceæ. In *Euastrum*, after the scission has taken place, in each filial cell the one half is perfected entirely anew, whence in the younger condition this new half is small, almost spherical and colourless. Nägeli has shown this mode of propagation in *Euastrum margaritiferum*, Ehr. (p. 118, Tab. VII. A, fig. 2, *e*); whilst we had previously a description of this interesting process of division and growth in *Staurastrum* and *Euastrum*, by Ralfs (Ann. Nat. Hist., vol. 14, 1844, Pl. VI., VII., and vol. 15, 1845, Pl. X., XII.) and Focke (Physiol. Stud., Bremen, 1847, p. 47, Pl. II.).

Propagation by conjugation occurs in the Desmidiaceæ, which Nägeli (pp. 17, 18, Tab. VII., A. fig. 6 *h*) thus describes, in *Euastrum rupestre*, Näg. :—Two individuals are placed close together, and push out short processes, which meet, and by the absorption of the wall constitute a canal, into which the entire contents of the two cells thus connected enters, constitutes one mass, and is gradually formed into a single cell. Nägeli adds, however, that in Closterium this act of conjugation proceeds in a different way, which I can confirm. In *Closterium lunula*, according to Morren (Ann. d. Sc. Nat., tom. V. 1836—Botanique, p. 325, pl. 9) the conjugated individuals appear to grow together exactly in the way above described; in *Closterium rostratum* also, two individuals appear to become united by the middle of their body (Vid. Focke, l. c. pl. III. fig. 34-36, and Ralfs, Brit. Desmidieæ, 1848, pl. XXX. fig. 3 *c*); whilst *Closterium Dianæ, lineatum, striolatum, setaceum*, &c., behave in a totally different manner in this process. In these species the middle of the cell-membrane dehisces with a transverse fissure, and the entire contents, from two contiguous, opened cells, coalesce into a single rounded or angular mass. Sometimes (in *Closterium lineatum*) it is only the two upper and lower halves which thus coalesce, forming two closely approximated compressed globules. Relatively to this mode of conjugation I refer to the representations given in Ehrenberg, pl. V. and VI., as well as in Ralfs, pl. XXIV. to XXX. It remains to be inquired whether the green bodies produced by this conjugation, the covering of which, at first very delicate, gradually becomes thickened, are to be regarded as spores or as sporangia. I have not myself been able to observe what proceeds from the green bodies in course of time. According to Morren (*o. c.* p. 329, pl. 10), however, it would appear that in *Closterium lunula* the green spores arising from the conjugation grow into a new *Closterium* after they have emerged from their envelope and, like the spores of *Vaucheria*, move about freely in the water. This process, as is truly remarked by Focke and Nägeli, is not in any way one of multiplication, but properly a kind of reduction or diminution. I suppose, therefore, that the green bodies produced by the conjugation are not in all cases developed into a single Closterium, like spores, but that, as in the case of other Algæ, such as *Vaucheria*, *Œdogonium*, there are two sorts of spore formations, and that under certain circumstances these green bodies represent a germ—capsule or sporangium—in which, by a process of division, several young Closteria come to be perfected. With this mode of development, probably, is connected the vesicular body, containing sixteen small Closteria, figured by Ralfs (pl. XXVII.) as belonging to *Closterium acerosum*. According to Jenner (ib. p. 11) the covering of the green bodies in Closterium, which are regarded by Ralfs as sporangia, swells whilst a mucus is secreted within it, and minute Closteria are formed, which at last, by their increase, rupture the attenuated vesicular covering. Whether or no that form of gelatinous vesicle, containing eight young Closteria, which, according to Focke (*op. c.* p. 57, pl. III. fig. 27), proceeds, in *Closterium digitus*, from a process of envelopment, belongs to this category, I will leave undecided.

Ehrenberg has proposed (*o. c.*, p. 89) to designate these green bodies of the Closteria, produced by conjugation, as double buds, and the entire act of conjugation as a double gemmation. This designation, however, is quite inapplicable, since in any form of gemmation it is impossible that the entire contents of a cell, as is the case here, should germinate into the newformed bud. Ehrenberg, moreover, in the exposition of the organization and vital processes of the Closteria, perceived their similarity with those of the Zygnemaceæ (*Zygnema*, *Spirogyra*, *Zygogonium*, &c.), which are also propagated by conjugation. He says (*o. c.*, p. 99) that were any one readily disposed to look for similarities, it would be easy to speak of vesiculæ seminales, oviducts, and testes (in *Spirogyra*); but all is motionless; and just as motionless is everything in the *Closteria*. All those particulars, which, according to Ehrenberg, would serve to prove the animality of these organisms, either have no existence at all or are of no validity. He adduces four principal characters especially (*l. c.*, p. 88), which would exclude the Closteria from the vegetable kingdom.

1. They have spontaneous motion. The slow, turning, and at the same time rare movements of the Closteria, present no character of spontaneity; these motions are certainly merely the consequence of an active endosmosis and exosmosis, by which the water immediately surrounding the Closteria, and consequently themselves, are put into motion. 2. That they have an opening at each end. But these openings have not been seen by any other observer; the sharp-sighted Focke (*o. c.*, p. 55, 60), even, has been unable to perceive any. That Eckhardt (*o. c.*, p. 211; p. vii., fig. 1, *r r*) should have introduced these openings into his figure of Closterium acerosum—although they have not been observed in that instance, either by himself or by Ehrenberg—can decide nothing. 3. That they are furnished with conical, wart-like organs, projecting even from these two openings, which are in continual motion; but these organs, also, have not been discovered by any other observer. According to Ehrenberg, the number of these proboscis-like, motile organs is easily computed, since their basal portions, in the form of minute, continually moving papillæ, may be distinctly seen and counted in almost all Closteria. These papillæ, however, are nothing else than quivering masses of granules, in molecular motion, contained in two vesicular spaces. 4. Lastly, Ehrenberg refers to the transverse division observed in the Closteria, which, according to him, is to be indisputably regarded as irreconcilable with the vegetable character. That Ehrenberg is here altogether in error, will be admitted by any one who has at all studied the lower vegetable world. The Closteria, therefore, are not only as rigid as the Zygnemata, but have quite as much right to be regarded as belonging to the vegetable kingdom. No part of their body possesses that contractility and expansibility which is an attribute of the animal body alone. The progressive motion of granules and fluids, which has been noticed in *Clsoterium* by Meyen, Dalrymple, Lobarzewski, Focke, and Ralfs, does not proceed from any contractile part of the *Closterium* cell, but corresponds much more with the circulation exhibited in other plant-cells, as in *Chara*, *Vallisneria*, and the hairs of the Nettle, &c. But whether this motion of the fluids depends upon an

internal ciliary investment, as asserted by Focke (*o. c.*, p. 56), I may be allowed to doubt, as I have never been able to perceive such cilia in the Closteria; and my friend A. Braun, whose opinion on such a matter is of the utmost value, has been equally unsuccessful. Since the Closteria, as well as the rest of the Desmidiaceæ, are certainly plants, it follows that conjugation, or zygosis, as a special kind of propagation, does not belong to the animal kingdom, unless Kölliker's observation, of the coalescence of two individuals of *Actinophrys Sol*, should be regarded as an analogous process. There is nothing contradictory in the notion that such a conjugation should exist in *Actinophrys Sol*, a protozoon of so simple a kind, whose structureless body, according to Kölliker's late researches, consists of a homogeneous, contractile substance, without mouth, intestine, or other organs. I would, on the other hand, ask those who, with Ehrenberg, not only regard the Closteria as animals, but are, besides, under the erroneous impression that these creatures possess a very complex, motile apparatus, polygastric digestive organs, male and female sexual organs—I would ask them what becomes of this motile apparatus,—of the various stomachs, ovaries, and testes,—when all these parts, with the rest of the contents of the two cases which enclose these so-termed complete animal organisms, have coalesced in the act of conjugation?

A third mode of propagation, viz. a free cell-formation, in which the contents of the mother-cell are employed as a nutritive material, in the formation of the filial cells, and, consequently, in which the death of the mother-cell is involved, would appear, according to Nägeli (p. 17), to be restricted to the orders of the Protococcaceæ and Valoniaceæ. Whether such a production of filial cells within a mother-cell does not occur in certain Palmellaceæ and Desmidiaceæ, which have been confounded with Infusoria, I must leave as doubtful.

[To be continued.]

REVIEWS.

Lectures on Histology, delivered at the Royal College of Surgeons of England, in the Session 1850-1. By John Quekett. London, Baillière.

[Second Notice.]

Want of space compelled us to defer further notice of Professor Quekett's work in our last number. We shall now make a few remarks on that portion devoted to animal histology.

Those who are less acquainted with vegetable than animal tissues will wonder that a larger proportion of this work is devoted to plants than to animals. We have already stated our opinion that the best introduction to the study of animal cells is the study of the cells of plants, and we think in a limited course Mr. Quekett has done wisely in thus dwelling on the simpler forms of organization. Having said so much upon the vegetable histology, our remarks must be rather illustrative than critical on the remaining portion of this volume. The following table will serve as a guide to the subjects treated in this department:—

"1. Simple membrane: employed alone or in the formation of compound membranes	Examples:—Walls of cells. Posterior layer of the cornea. Capsule of lens. Sarcolemma of muscle, &c.
2. Fibrous tissues	White and yellow fibrous tissues. Areolar tissue. Elastic tissue.
3. Cellular tissues	Cartilage. Adipose tissue. Pigment. Grey nervous matter.
4. Sclerous or hard tissues	Rudimentary skeleton of invertebrata. Bone. Teeth, &c.
5. Compound membranes: composed of simple membrane, and a layer of cells of various forms (epithelium or epidermis), or of areolar tissue and epithelium	Mucous membrane. Serous and synovial membranes. True or secreting glands.
6. Compound tissues: *a*, composed of tubes of homogeneous membrane containing a peculiar substance .	Muscle. Nerve.
b. Composed of white fibrous tissues and cartilage	Fibro-cartilage."

The descriptions given of the structure of membrane, of areolar tissue, and of yellow fibrous tissue, are all good, and contain many original observations. The structure of the various forms of cartilage is also described with great accuracy. There is now no question as to the non-vascularity of these tissues, but in a state of disease, the blood-vessels by which they are surrounded increase in size, and render them what are called vascular.

"In a specimen from a diseased joint, which after removal was carefully injected, numerous vessels may be observed passing through the cartilage; they are derived from the vessels of the shaft, as the articular lamella being involved in the disease, permits the vessels to pass through it; they proceed in straight lines through the cartilage to the free articular surface upon which they form a network, and anastomose with others probably derived from the synovial membrane. The subject from whom this specimen of cartilage was obtained was fifty years of age, and the disease had existed for nearly twelve months. A preparation which belonged to the late Mr. Liston, and which he was in the habit of exhibiting in his Lectures, consists of the head of the tibia, with diseased cartilage attached. Not only can vessels be seen by the naked eye, passing from the bony shaft into the cartilage, in the form of loops, but a rich network may in some cases be observed upon a large portion of the articular surface. As far as I have been able to learn from examinations of diseased articular cartilages, especially those affected with ulceration, I conclude that the change first takes place in the cartilage cells, as is made evident by their becoming rounder and much larger in size, and by their contents assuming a different character, the nuclei disappearing, and globules of oil taking their place. In some cases these oil-globules are of very minute size, and the cells then appear granular; as the disease goes on, the cell-walls are absorbed, a series of cavities are formed, all the hyaline substance in the neighbourhood becomes more or less fibrous, and ultimately blood-vessels are developed in the fibrous tissue."

There is a series of valuable observations on Enchondroma. In order to explain this structure he gives an account of the structure. Speaking of the different views entertained on the formation of the lacunæ, he says—

With regard to the formation of the lacunæ of bone, two views are now entertained by different histologists. The first is that given in the 'Physiological Anatomy' of Professors Todd and Bowman, in which it is stated that the lacunæ are developed from the nuclei of the cartilage-cells: the other that of Mr. Tomes, published in 'Todd's Cyclopædia,' article 'Osseous Tissue,' in which it is asserted that the lacunæ are not developed from the nuclei of the cartilage cells, but are cavities left in the newly formed bone, from which canaliculi are subsequently developed. The last described specimen of enchondroma, however, tends to prove that the view entertained by Todd and Bowman is the more correct.

Of softening of the bones he says—

In *Mollities ossium*, there is a deficiency of the earthy constituent of the bone. The change first begins in the lacunæ, which become larger and larger, and the bone around them more and more transparent; finally, several lacunæ unite to form one cavity, which, however, does not long remain empty, but is occupied by a soft kind of adipose tissue, so that such bones are always extremely thin and full of fat. For this reason, *Mollities ossium* may be considered as an example of the fatty degeneration of bone.

Of all the subjects to which the attention of the morbid anatomist has been directed of late years there is none perhaps of more practical importance than that of fatty degeneration, more especially of the muscular tissue. We are chiefly indebted for our knowledge of this condition of the muscular tissue to the labours of Dr. Ormerod and Dr. Richard Quain. Mr. Quekett gives a good account of this morbid condition, and previous to doing so describes the structure of healthy muscular tissue. The following is his account of the fasciculi:—

> The fasciculi exhibit transverse and longitudinal striæ, but, in most cases, the former are more plainly exhibited than the latter. In some animals the fasciculi break up transversely, in others longitudinally, so that, in the one case, we have a series of discs, and in the other numerous filaments termed fibrillæ. The fasciculi of the eel readily break up into discs, whilst those of man and most mammalia commonly separate into fibrillæ. If the flat surfaces of the discs be examined, they present a granular aspect, which is due to their being made up of the ends of the fibrillæ; and, if the fibrillæ be viewed with a power of five hundred diameters, each one will exhibit a beaded structure, the part forming the bead being a minute portion of muscular substance, termed *myoline;* but if the power be increased, the masses of myoline will be found to be surrounded by a thin cell-wall. In the muscular substance of the eel, the structureless sarcolemma surrounding a fasciculus is readily seen.

This we believe to be a true account of the muscular tissue, and we cannot imagine that an unprejudiced observer, with a good instrument, could contort the square masses of myoline into a spiral form. Such, however, is the result of some recently published researches. On the diseased condition Mr. Quekett remarks:—

> "Before fatty degeneration commences in voluntary muscle, the transverse striæ disappear; and I have long known that the first trace of this disease is marked by a disturbance of the particles of myoline, which appear as so many very minute granules scattered irregularly within the sarcolemma, leading one to suppose that the delicate cell around each particle had given way, thereby allowing the myoline to escape, and destroying all regularity both of the transverse and longitudinal markings. As the disease progresses, the myoline is replaced by minute, highly-refracting globules of oil, until at last the whole sheath is full of them.
>
> In a specimen of this diseased condition of muscle from the human subject, the transverse striæ are visible in the upper part, and a partial disturbance of the myoline in the lower; in another preparation the disease has so far advanced that all trace of striæ is completely lost, and globules of oil, in this case of nearly equal size, but in others of variable diameter, occupy the sarcolemma. The fibres of the heart are very subject to fatty degeneration, and for our knowledge of this disease we are, in a great measure, indebted to the labours of Dr. Ormerod; but the subject has been lately investigated with great care by Dr. Richard Quain; and in his paper, published in the fifteenth volume of the 'Medico-Chirurgical Transactions,' you will find all that is at present known respecting it. A very excellent example of fatty degeneration of the muscular fibres of the heart, is one taken from a man a hundred and three years of age, for which I am indebted to the kindness of Dr. Edward Smith; it exhibits the transverse striæ in some parts, but in others these are replaced by highly-refracting globules of oil. I have lately had the opportunity of examining a most interesting case, in which the disease was present in the voluntary muscles of the extremities. In one family

of nine children, six of whom were girls and three boys, all the girls were perfectly healthy, but the boys, on arriving at the age of three or four, began to lose the use of their limbs. One of them, the eldest, has lately died, and, on examination of the brain and spinal chord, both were found to be healthy; the muscle, however, had not only undergone fatty degeneration, but the fasciculi themselves were much diminished in size, which would, of course, account for the want of power in the limbs. This disease from the first was supposed to be seated in some part of the nervous system, probably arising from imperfect innervation of the muscle; but the discovery of its real seat will, it is to be hoped, lead to such a mode of treatment as may be beneficial to the two afflicted survivors."

We have yet to discover the causes of this terrible condition of the tissues of the human body. That it is brought on by want of action in the muscles is shown by its occurrence in paralysed limbs and in those muscles of animals which do not perform their normal functions. The most fearful seat of its attacks is the heart: when once it seizes this organ its action is impaired, and frequently sudden death is the result. In this case it is probable that the blood is first at fault and leads to the abnormal nutrition of the muscular fasciculi.

In the section on adipose tissue we find a statement of some interest.

"In all works on anatomy and physiology, even of so late a period as last year, it is distinctly stated, that adipose tissue exists in invertebrate animals; this, however, I find to be incorrect, and it cost me no small amount of labour to prove it. Fat certainly does exist in insects, crustacea, and mollusca, but no true adipose cell is ever present; it could not be nourished without its accompanying blood-vessels, and these are not found in invertebrata. The tissue resembling adipose tissue usually belongs to the liver or other glandular organ, and the fat exists in its cells in the form of oil.

In the liver of the larva of a goat moth, *Cossus ligniperda*, which consists of a series of cells or vesicles, containing a large number of globules of oil; and again, in another specimen, taken from a cockroach, there are tubes, also full of oil globules, but in neither case, and not even in the *Cephalopoda*, is the oil contained in adipose cells.

As soon, however, as we pass the barrier between the invertebrate and vertebrate sub-kingdoms, we find that even in the lowest members of the class of fishes, true adipose cells occur, and all are doubtless aware, that in the liver of the cod, and of many cartilaginous fishes, fat exists in the form of oil without any adipose tissue;—in this particular, the liver resembles that of an invertebrate animal."

The almost universal presence of oil in the tissues of animals is an interesting fact, and one the full import of which is not perhaps at present well understood. We have here a fruitful subject for microscopic research.

But we must conclude. The publication of these lectures will make all who are interested in microscopical investigation anxious for further remarks from Mr. Quekett. At present he has only given the outlines of histological inquiry, and much is to be expected from one who so honestly observes and gives his opinions. In our notice we have omitted all reference to the wood-cuts which accompany the volume, but they are very numerous (159 in number), well executed, and all original. It is not often nowadays that one gets such a stock of new matter to draw upon. All those interested in histology will be glad to have this volume in their library.

Report of the Proceedings of the Pathological Society of London.
Sixth Session, 1851-1852.

The number and value of the contributions to microscopic pathology in this volume of Reports of the Pathological Society are such as fully to justify a notice of it in our Journal. These contributions constitute, in fact, a main feature and no little part of the book, and add very materially to its interest and utility. Their number shows the extent to which microscopical investigations of the highest practical importance are carried by the rising generation of medical men; and the manner in which they have been carried out, as displayed in this volume, is a most satisfactory proof of the technical skill and care of the observers. It is clear that the gross and coarse pathology of former periods, as well as the kindred physiology and anatomy of the same times, is rapidly and effectually giving way to the more refined analysis for which the microscope, in its improved and still improving form, affords the means.

Amongst the more generally interesting and valuable of these contributions we have only space to refer, and that briefly, to a few.

From Dr. W. Jenner we have "An Account of Crimson or Hematoid Crystals, and Calcification of the Minute Arteries of the Cerebrum" (p. 239); "A Description of a case of Cancer in the Posterior Mediastinum" (p. 253); "Of a very curious case of what is here termed Colloid Disease of the Abdominal Viscera" (p. 323). Of the microscopical appearances in this case a very careful and detailed account is given. Among the interesting points, Dr. Jenner refers to the close resemblance of certain phosphate of lime granules to olein, and to the resemblance borne by the fat imbedded in the colloid matter to cells. He directs attention especially to the close resemblance—a resemblance so close that he could give no visible characters whereby the one may be distinguished from the other—between the phosphate of lime and fat. These globules, which, judging from the eye alone, experienced microscopists pronounced to be oil, were dissolved completely in hydrochloric acid. He conceives that the phosphate of lime was deposited chiefly in the interior and nuclei of the epithelial scales lining the inner surface of the cells or cysts in which the colloid matter was contained. A very nearly similar report on the same case is given by Dr. R. Quain. From Dr. Jenner we have also a "Report on the Microscopic Appearances in a Morbid Growth from the Cranial Bones" (p. 416).

Several of Dr. R. Quain's reports have reference to cases of fatty and fibrinous degeneration of the muscular tissue of the heart. With the former of these modes of atrophy Dr. R. Quain' s name will always be intimately connected; and we need not say that what he may state on the subject is always worthy of attention.

He also gives an account (p. 247) of a "Case of Malignant Tumour in the Brain," with reference to which it is remarked that

> " the extremely close resemblance which this tumour bore in its general appearance to an old apoplectic effusion was a remarkable fact well worth attention, and the result showed how very valuable is the aid of the microscope in determining the nature of these and similar lesions."

In a case (p. 254) in which the rare combination of encephaloid tumour (in the anterior mediastinum) and tubercle was met with, Dr. R. Quain gives the following Report on the Microscopic Characters of the diseased Tissues :—

" *Encephaloid Mass.*	" *Tuberculous Deposit.*
" 1. On section of a pearly-white colour; spotted freely with vascularity and with apparently effused blood.	" 1. Of a pale yellow or buff colour, not presenting any appearance of blood or blood-vessels.
" 2. Of solid (elastic) consistence, but friable, yielding, on gentle pressure, a quantity of viscous pearly-coloured fluid or juice.	" 2. In some portions solid and tough, in others of a cheesy consistence, and in others of that of thick cream; the solid parts not affording fluid or juice on pressure.
" 3. With the microscope found to consist of a great number of cells enclosed in large meshes, formed by the interlacement of bundles of a filamentous tissue, *sui generis*. The cells are rather larger than blood corpuscles, are of all shapes, but generally spherical, and contain from one to five nucleoli. These are rendered more distinct by acetic acid. Few cells contain distinct nuclei. There are also numerous compound granule or mulberry cells, and in many parts oily particles. Blood-vessels and blood-globules abound.	" 3. With the microscope found to consist of cells, granular particles, and fragments of broken-up fibres; also to contain some fine filaments, disposed without arrangement, and evidently derived from the lung texture. The cells, which are mostly spherical, are smaller than those from the encephaloid mass, and contain apparently more numerous and much smaller granules. These, as in the latter, are rendered more distinct by acetic acid. Oily particles are seen, more especially in the softened matter. Neither blood-globules nor vessels are seen."

In a case of fatty degeneration of the heart (p. 263), and in which rupture of that organ took place, the affection appears to have been local or circumscribed, the muscular fibre in other parts of the heart being in a remarkably healthy condition. The local degeneration or atrophy was evidently connected with a diseased condition of a branch of the coronary artery distributed to this part of the heart. Dr. Baly reports another case of rupture of the heart consequent upon fatty degeneration, and in this case also, the alteration seemed to be more local than general; but the condition of the coronary arteries is not adverted to. Fatty degeneration was present in some of the cerebral vessels in the same case. In another case of ruptured heart, with local fatty degeneration, recorded by Dr. Quain, the anterior branch of the coronary artery, leading directly to the disease, was seen to be greatly ossified, and, about the middle of its course, completely obstructed.

Dr. Bence Jones reports a case in which *Sarcina ventriculi* was found in the urine of a boy. In the present case it seems pretty clear that this was accidental, and that the *Sarcina* really came from the stomach, but at the same time we would observe, that it does not appear to be possible to account for the presence of *Sarcina* in the urine *in all cases* in the same way. In the cases recorded by Heller (Archiv. d. Chemie, u. Mikroskopie, Heft 4, 1847, and Heft 1, neue Folge, p. 30, 1852) there seems every reason for the belief that the *Sarcina* was produced in the urine itself. In the latter of the cases described by Heller the *Sarcina* occurred not merely mixed with other sediments, but in such quantity as to form a loose, white deposit an inch in height, composed wholly of the *Sarcina*, or with a slight admixture of carbonate of lime. It is interesting that in all these cases of *Sarcina* in the urine recorded by Dr. Heller there were symptoms indicative of cerebral or other nervous lesion. Dr. J. H. Bennett, in his Lectures on Clinical Medicine (p. 214, 1851), notices a case related by Dr. Mackay.

Microscopical observations on the so-termed serous cysts in the kidney are afforded by Drs. Brinton and Bristowe and by Dr. Bence Jones, who examined their contents chemically. These observations, however, leave the *vexata questio* of the genesis of the cysts very much as it was.

Dr. Bristowe assigns reasons (pp. 380-1) for the conclusion that they cannot be Malpighian bodies ("at least, not healthy ones," he oddly adds), which do not appear to us altogether so cogent as he would seem to think them; and that they are not dilated tubuli he thinks is sufficiently shown by the circumstance that he has never seen a cyst continuous with a tube—a condition, we should imagine, not likely to occur, seeing that the complete occlusion of the tube on each side is indispensable to the formation of the shut cyst. He also dismisses the notion of their being "fresh formations arising from cytoblasts" as untenable; and he is consequently obliged to confess that he is unprepared to say how these cysts arise.

In the next case (pp. 381-2), which is reported upon by Drs. Brinton and Bristowe, it would appear that the microscopic cysts differed in some respects from those in the former: they were much less uniform in size—sometimes solitary and sometimes clustered: they could be readily isolated and moved about the field of the microscope. They varied greatly in magnitude, the smallest being little larger than renal epithelial cells, the largest about the size of Malpighian bodies. The observations of Drs. Brinton and Bristowe would seem to have been limited in great measure, though not entirely, to the minute microscopic cysts. Dr. Bence Jones refers more particularly to the larger ones. In the contents of these he was unable to discover any of the elements of urine, nor could any epithelial lining be detected. It is left to be inferred from this, at least we presume so, that these large cysts could not be dilated tubuli. But again, this conclusion seems to have been drawn hastily. The strongest point in the argument is perhaps the absence of epithelium on the inner surface of the cyst. But the force of this circumstance, perhaps not in itself of such very great importance, is, at all events, much invalidated by the certain fact that these cysts do occasionally exhibit an epithelial lining. Perhaps they must be examined in a very fresh state to show it; but that such a lining does sometimes exist is within our own observation. The truth of the matter after all may be this: that the serous cysts are of different kinds; that some, as in Dr. Bristowe's first case, are due to dilated Malpighian capsules; that others, as the smaller ones in the second case, originate in dilated epithelial cells; and lastly, that the larger ones are dilated tubuli, that is, in their advanced condition. They may have originally commenced in one of the second class. This opinion, which has long appeared to us likely to afford a more satisfactory explanation of these cysts than one more exclusive can do, we are glad to find coincides with that of Kölliker (Manual of Human Histology, pp. 477-8), who also fully confirms Dr. Johnson's view by an observation of his own.

Our space will merely allow us to refer to Mr. Toynbee's valuable contribution to the knowledge of Tubercle (p. 385); and to Dr. Bristowe's account of "A Malignant Disease of a Cystic Ovary" (p. 404, with plate); as well as to Mr.

Quekett's "Comparative view of the Condition of the various Muscles in three cases of Non-Congenital Club-foot"—all more or less instances of atrophy. With reference to the figures (pl. xii.) belonging to this paper, we should much like to have had Mr. Quekett's explanation of the appearance presented by fig. 2. Were not such a thing almost impossible, one might deem that Dr. Barry's contorted views on the structure of muscular fibre had found confirmation to some extent in the hands of the Professor of Histology of the Royal College of Surgeons.

LEUCOCYTHEMIA, or White-Cell Blood, in Relation to the Physiology and Pathology of the Lymphatic Glandular System. By JOHN HUGHES BENNETT, M.D., F.R.S.E. Edinburgh: Sutherland and Knox.

No branch of science has been benefited by the employment of the microscope so much as physiology. So great, in fact, have been the advantages accruing to the study of vegetable and animal histology by the aid of this instrument, that it is regarded by some scientific observers as exclusively the property of this branch of science. Although physiology had latterly made rapid strides by the aid of chemistry, especially when applied in the investigation of the first and last facts of a given series of phenomena, it still failed to supply the means of examining those intervening links in the chain which occurred within the organism of plants and animals. In revealing the great fact that animal and vegetable tissues are principally composed of cells, and that all the functions they exhibit are the result of the properties of individual cells, the microscope laid the foundation of a true science of life. Since its first application in this direction, the physiology of plants and animals has become a new science; the old systems are gradually retiring, and everywhere more accurate and profounder views of the nature of life and organization are supplanting doctrines which had become venerable only for the want of the means of testing their truth. At the same time that the microscope is furnishing the means for a more philosophic study of the functions of plants and animals, it promises to render their study more definitely available for the practical ends which the medical practitioner has in view. The success of empirical practice, and the encouragement given to irregular systems of treating disease, have not arisen so much from the ignorance of the public, as from the comparatively feeble assistance which the prevailing doctrines of physiology and theories of disease were capable of affording to the most learned physician. This time is passing by, and the microscope, in conjunction with a chemistry which, if it cannot imitate, is at least beginning to trace accurately the changes undergone by the elements contained in a living cell, is hastening the time when physiology shall pass from the speculative to the certain sciences, and medicine no longer remain a conjectural art. Already has it pointed out the differences between diseased and healthy tissues, and afforded a means of diagnosis which did not previously exist. The secretions, the contents of the viscera, and above all the blood, can be examined with an accuracy which seems to promise a sufficient means for working out the phenomena of health and disease.

These general remarks have naturally occurred as introductory to the notice of a book which describes a disordered condition of the blood, which could only be detected by the microscope, and which presents us with inferences from the conditions thus observed, having a wide range of application, and embracing the discussion of most important generalizations. The condition of the blood described is called by Dr. Bennett *Leucocythemia* (λευκὸς κυτος αἷμα), and consists essentially in the presence of a larger number than usual of white cells amongst the red globules of the blood. The work contains a record of thirty-five cases in which this condition was observed before or after death. The mode of ascertaining the condition of the blood whilst the patient was living was to puncture slightly the end of the finger with a lancet. On placing a drop of the blood thus procured under a microscope, the coloured corpuscles were found to collect together in rolls, whilst the colourless corpuscles filled up the intervening space. Acetic acid was found to dissolve up the coloured bodies, and to render the colourless ones very transparent. The latter, thus treated, presented a nucleus, in some consisting of a single round or oval body, but in the majority presenting two, three, or even four granules, each having a depression in its centre. Sometimes the nucleus was crescentic, or in the form of a horseshoe. These appearances were presented in most of the cases examined. It is difficult to estimate the proportions of the corpuscles, but Dr. Bennett states that, when all the meshes or interspaces between the coloured corpuscles are filled up with colourless ones, the latter may be estimated at one-third.

After detailing the cases with great accuracy, the author enters into a variety of general considerations, to some of which we would draw attention. One of the most remarkable facts in connection with this condition of the blood is the almost constant presence of disease of the spleen and lymphatic glands. Of nineteen cases in which the body was examined after death, the spleen was enlarged in sixteen, and the lymphatic glands were more or less diseased in eleven. The chapter on the diseased condition of bodies presenting the white-cell blood is followed by a discussion on the relation existing between the colourless and coloured corpuscles of the blood, and the origin and destination of the blood corpuscles. We cannot follow the author through this argument, but give his conclusions :—

> "1. That the blood corpuscles of vertebrate animals are originally formed in the lymphatic glandular system, and that the great majority of them, on joining the circulation, become coloured in a manner that is as yet unexplained. Hence the blood may be considered as a secretion from the lymphatic glands, although in the higher animals that secretion only becomes fully formed after it has received colour by exposure to oxygen in the lungs.
>
> "2. That, in mammalia, the lymphatic glandular system is composed of the spleen, thymus, thyroid, supra-renal, pituitary, pineal, and lymphatic glands.
>
> "3. That, in fishes, reptiles, and birds, the coloured blood corpuscles are nucleated cells, originating in these glands; but that, in mammals, they are free nuclei, sometimes derived as such from the glands; at others, developed within colourless cells.
>
> "4. That, in certain hypertrophies of the lymphatic glands, their cell elements are multiplied to an unusual extent, and under such circumstances find their way into the blood, and constitute an increase in the number of its colourless cells. This is leucocythemia.
>
> "5. That the solution of the blood corpuscles, conjoined with the effete matter derived from the secondary digestion of the tissues, which is not converted into albumen, constitutes blood fibrin."—p. 112.

Dr. Bennett then enters upon the consideration of various pathological conditions, on which his investigations on the nature of white-cell blood seem to throw light. By far the most important of these is inflammation. It is a prevalent notion that the accumulation of the colourless corpuscles within some of the smaller vessels is an essential condition of this important pathological condition. The discovery of white-cell blood, in which the colourless corpuscles of the body abound, must be regarded as opposed to this view. Dr. Bennett says—

> "On the other hand, every known fact convinces me, and the progress of science only adds strength to my convictions, that we must ascribe the ultimate cause of inflammation to a derangement of those forces which regulate the nutritive powers of the economy, and that the only correct definition of inflammation itself is—an exudation of the normal liquor sanguinis. It is in vain that physiologists seek in the alterations of the vessels on the one hand, or in morbid changes of the blood on the other, for the primary cause of this important condition. Facts prove that both are more or less affected, and also show that neither the one change nor the other, nor the two combined, constitute inflammation. The vital properties

of the tissues (understanding by these the unknown conditions necessary for carrying on the nutritive processes) are in all such cases deranged, and such alteration is the cause of the changes which have been referred to, and not the effect."—p. 115.

The work is accompanied with two coloured lithographs and a large number of woodcuts illustrative of the condition of the blood globules. It will be read with interest by the medical man, and is a capital instance of the value of the microscope in the practice of medicine, not only as affording the facts on which alone sound physiological theories can be based, but as the only means of discriminating between many very different pathological conditions.

Handbuch der Gewebe-lehre des Menschen für Aerzte und Studirende, mit 313 Holzschnitten. Von A. Kölliker, Prof. d. Anat. u. Physiol. in Wurzburg. (Handbook of Human Histology, for Practitioners and Students, with 313 Woodcuts. By Prof. A. Kölliker.)

"Medicine has arrived at such a stage that Microscopical Anatomy appears to form its foundation, as much as the anatomy of the organs and systems; and a thorough study of Physiology and Pathological Anatomy is impossible without an exact knowledge of the most minute formal elements. It becomes then the duty of those who cultivate this field of science not only to communicate their observations to their fellow-workers and to those who are more profoundly acquainted with medicine, but to enable all those who are concerned with the study of Man, and especially students and practitioners, to profit thereby. The present work seeks to perform this task by giving as condensed as possible a view of the relations of the elementary parts of the body and of the more minute structure of the organs; avoiding all polemical discussions, with the exception of a few of the more important points as yet *sub judice,* and leaving the history of the science completely in the background; but, on the other hand, entering as fully as possible into those points which bear upon Physiology, Pathological Anatomy, and Comparative Histology."

Such is Professor Kölliker's preface to the very admirable work in which he exhibits the result of his manifold and long-continued microscopical researches into the structure of the human body. Nor has Professor Kölliker's performance fallen short of these his professed intentions. Any one who will carefully study the work will, we think, agree with us, that since the publication of Henle's 'Allgemeine Anatomie,' ten years ago, no histological manual has appeared in any country* at all comparable with it for exact research in matters of detail, for completeness as a whole, for breadth of view, and last, but by no means least, for the conscientious care with which the author has in almost every case made

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* Our readers will think we have forgotten the admirable work of Todd and Bowman; but it has never been completed.

himself acquainted with the literature of his subject. We mention this good quality particularly, because we have been surprised to meet with one or two defects, arising, as we think, from the Professor's having overlooked good work performed on this side of the Channel. The chapter on the Blood, pp. 565-584, for instance, seems to us to be the weakest in the book; and we can hardly think it would have been so, had Professor Kölliker sufficiently studied the observations, published in this country so long ago as 1845, by Mr. Wharton Jones,* in a memoir which we consider to be one of the most important contributions ever made to our knowledge of this subject.

We have unfortunately no space to enter into a detailed criticism, but we must remark that Wharton Jones has here demonstrated (958) that the "stellate lymph corpuscles," figured by Kölliker (fig. 290), are formed by a peculiar shooting out of the wall of the lymph corpuscle, and not by any "exit of their contents." (Kölliker, note, p. 565.) Professor Kölliker is one of those who have paid most attention to the phenomena of contraction presented by simple cell membranes, but he has forgotten to mention one of its most extraordinary and earliest discovered instances—that Amœba-like motion of the "colourless corpuscle," described by Wharton Jones, in the blood of the skate, frog, &c. (loc. cit., § 9-24), and quite readily visible by any one who looks carefully after it even in the human "colourless corpuscle."

There is yet a process which Professor Kölliker takes pretty much for granted—we refer to a supposed natural division of the nucleus of the colourless corpuscle, and to the consequent occurrence of multiple and biscuit-shaped nuclei; but any belief in which, must, we think, be greatly shaken by the perusal of §§ 29-30, 63-66, of Wharton Jones's Memoir, and by the repetition of his experiments (we have often repeated them in man) be completely destroyed. Certain it is, that the more gradually and carefully the re-agent is applied, the more certain is one to find the colourless corpuscles of the blood with only circular nuclei, while, if it be applied suddenly and concentrated, one is almost equally certain to find them with nuclei of every irregularity of shape, from biscuit-shaped to mulberry-shaped.

Finally, considering that "the origin of the blood corpuscles after birth and in the adult" is "one of the most obscure portions of the history of the blood-cell" (Kölliker, p. 581), we

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* Philosophical Transactions, 1846, Part II., "The Blood Corpuscle considered in its different Phases of Development in the Animal Series."

think that the very strong arguments, not to say the complete demonstration, contained in the memoir so often referred to, that the blood corpuscle is the free *nucleus* of the "colourless corpuscle," deserved grave consideration, and, at any rate, should not have been passed over in silence. Professor Kölliker's own view, that the red corpuscles are the small lymph corpuscles (Chylus Körperchen), which have lost their nucleus and become coloured, is, we think, totally untenable.

We regret to have had to find any fault with a work which is, in so many respects, faultless. It is only our sense of the great influence it is likely to have which has compelled us to do such violence to our feelings of gratitude towards its author.

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xii. 1er Partie, pp. 169. 1849.

1. MICROSCOPIC OBSERVATIONS ON THE STRUCTURE OF MUSCULAR FIBRE.

By DR. J. L. PREVOST.

NOTWITHSTANDING the profession with which the author commences, of his intention to give a more precise description of muscular fibre than had previously appeared, we are unable to perceive that this laudable object has been in the slightest degree carried out. There is little or nothing in the paper worthy of notice, and the illustrations are equally useless. It is only surprising that so lately as 1849 such a description of the mode of origin of muscular fibre could have appeared as this:—

> "Fibrine is the principal constituent of muscles. Soluble in the blood, it circulates with it, and is eventually deposited on the cellular framework, which determines the form and direction of the muscular fibres. This is seen very well in the embryo of the vertebrata. At first the voluntary muscles present rows of cellular cylinders, along which run numerous blood-vessels; shortly afterwards these cylinders are filled with organized fibrine."

He describes some experiments upon portions of muscle taken from the leg of *Carabus auratus*, in which the muscle was exposed to the action of solutions of strychnine, hydrocyanic acid, sulphate of morphia, and chlorine. According to him the isolated muscles of this insect will continue to exhibit contractile movements for twenty minutes or more when immersed in water. Strychnine, after producing violent contractions and elongations, (!) destroys this irritability in about ten minutes. Prussic acid acts, according to M. Prevost, more quickly, but the contractility even under its influence lasts for a minute or more, and morphia does not put it to sleep under eight minutes; whilst a solution of chlorine in water, strange to say, acts as an invigorating agent, for under its agency the movements are said to have persisted for half an hour or more.

It is needless to remark upon such experimental results as these.

2. Note Relative aux Apparences Microscopiques des Cheveux Humains et des Poils d'Animaux. By M. A. Morin.

A murder having been committed some months previously on the person of a forest-guard, in the Pays de Gex, M. Morin and another were charged with the duty of determining whether a hair, three lines long, found on the handle of an axe, taken in the house of a suspected person, were that of a man or of some animal.

The author adverts to a previous case of an analogous kind, which occurred in 1837, and, according to him, is the only one; it is reported by M. Olivier d'Angers.

M. Olivier appears to have distinguished human hair from that of the horse and ox, simply by the existence in the former of a central canal. Notwithstanding this absurd notion, which could only have arisen in an optical delusion, his decision happened by chance to be correct.

M. Morin, who appears to be equally ignorant of any sufficient distinction between the hairs of man and certain domestic animals, also arrived at what was probably a correct result. The only distinctive character upon which he seems to lay any stress consists in this,—that, according to him, the human hair possesses a general transparency, which is wanting in the others! Neither of these cases, though the decision of the question in both was probably right, should be cited as an instance of the useful application of the microscope to medico-judicial inquiries. M. Morin gives several figures of different hairs, but they are coarse and useless.

A Popular History of British Zoophytes. By the Rev. D. Landsborough, D.D. London: Reeve and Co.

A Catalogue of Marine Polyzoa in the Collection of the British Museum. Part I. By George Busk, F.R.S. Printed by Order of the Trustees. 1852.

These two works, though not of large size, are yet of interest to a large class of microscopic observers, and especially to those who devote attention to the attractive subject of marine zoophytology. The first of them, which forms one of Mr. Reeve's well-known series of popular works on Natural History, is from the welcome pen of Dr. Landsborough. The arrangement followed by the author is that of Dr. Johnston, to whose classical and most valuable work on the same subject* he confesses himself to be mainly indebted for the substance of his own compendium. Several new species, however, are described, and the figures are for the most part original and from nature. These figures exhibit numerous species, both in the natural size and magnified; they have been remarkably well etched on stone by Mr. Achilles. The second work, of which we here have only the first part, contains sixty-eight plates—containing magnified figures, drawn to a scale, of about 123 species, constituting a portion only of the Celleporina of Dr. Johnston, or of what the author (Mr. Busk) terms the "Cheilostomata." It also contains an arrangement of the species of this numerous and much-neglected class, differing in some respects from any former one; and short, descriptive, and distinctive characters of the various Orders, Sub-orders, Families, Genera, and Species, and the habitats of each species. The work, when complete, will afford, to a certain extent, a means for a more accurate comparison between the different species, and a more satisfactory view of their distribution on the surface of the earth, than has hitherto been possible. We defer a more detailed notice of this catalogue until such completion has been effected, here merely observing that the present part contains the Families Catenicellidæ — Salicornariadæ—Cellulariadæ — Scrupariadæ—Farciminariadæ—Gemellariadæ—Cabereadæ—Bicellariadæ—and Flustradæ.

Atlas der Physiologischen Chemie. (Atlas of Physiological Chemistry.) By Dr. Otto Funke. Leipsic: Engelmann. London: Williams and Norgate.

This work consists of fifteen plates, with six microscopical subjects on each plate, and is intended as a supplement to Dr. Lehmann's admirable Manual of Physiological Chemistry. The English reader already possesses a translation of this work by Dr. Day, published by the Cavendish Society. The publication of this Atlas will not only be acceptable to those who possess that work, but to all who are interested in microscopical chemistry. A reference to Dr. Lehmann's work will clearly show that there are many products of great interest in

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* A History of the British Zoophytes. By George Johnston, M.D., LL.D. 2nd edit. 1847. Van Voorst.

the blood and secretions of the human body which, although they have a complicated chemical structure, are yet easily recognised by means of the microscope. A knowledge of the forms which these substances assume will be easily acquired by means of the present Atlas. These illustrations, however, are not confined to chemical compounds, but wherever particular conditions of the solids or fluids of the body have been referred to by Dr. Lehmann, needing the microscope for their elucidation, they have been given by Dr. Funke. The plates are lithographed, and, wherever colour is required, it has been done from the stone, and we may point to them as good examples of what may be accomplished for the illustration of microscopic objects by these processes.

CURIOSITIES OF THE MICROSCOPE. By the Rev. Jos. H. WYTHES, M.D. Philadelphia: Lindsay and Blakiston.

IN our last number we noticed a work by Dr. Wythes, in which we pointed out a number of plagiarisms, without the slightest acknowledgment. We are sorry to have to announce that the present work is, if possible, a still worse instance of the appropriation of the literary property of others. The design of this work, like that of the last, is good, but, as in that work, it is badly carried out, and scarcely a sentence can claim to be regarded as original. The work consists of descriptions of microscopic objects, with plates, for the use of young people. The principal subject treated of is the family of Infusoria, and the plates and descriptions are directly copied from a work by Miss Agnes Catlow, published by Messrs. Reeve and Benham, with the title of 'Drops of Water.' On account of the proved plagiarism of this part of the work, we understand the publishers of Miss Catlow's book have been enabled to prevent the further sale of the American work. We have felt it our duty to call attention to this gross violation of the rights of authorship, and regret to find that it has been perpetrated by a gentleman who claims by his titles to belong to both the medical and clerical professions.

NOTES AND CORRESPONDENCE.

On Microscopical Re-agents.—The list of re-agents, and the instructions for using them, given in your last number, cannot but be useful to all who are commencing the study of the Microscope. There is, however, one point connected with these re-agents of such vast importance that I cannot forbear urging it on your notice, in the hope that you may devote some portion of your space to its discussion and elucidation: I refer to the various and unusual crystalline forms which many re-agents assume when they meet under the microscope. Without a knowledge of these singular facts, and without a perfect recognition of the crystalline forms, errors in micro-chemical investigations cannot but occur. I will illustrate my meaning by a few examples, which must be familiar to many observers, but which I do not happen to have seen noticed.

1. Liquor potassæ is a common re-agent in microscopy. Itself a liquid, and its principal combination with carbonic acid being a highly deliquescent salt, no agent could be thought more free from possible fallacy. If, however, a drop of potash be allowed to evaporate on a slip of glass, crystals appear, some of which are of a very remarkable form. They are chiefly six-sided tables, exactly like cystine. When in quantity they are often crowded together, as the cystine plates are, and sometimes exhibit a similar nucleus-like body in their centres. If a larger portion of liquor potassæ be put in a watch-glass, in a few weeks' time a mass of dry crystals appear, which are chiefly composed of innumerable needles aggregated together.

I at first thought that these crystals were the result of impurities, but on procuring some perfectly pure potash, the same as that which was used by Mr. Graham in his diffusion-experiments, the same phenomena were observed.

The crystals thus formed appear to be a carbonate of potash, but I have been unable to form them from the usual carbonates. I have tested these crystals carefully for nitric acid, without detecting any, and for sulphuric acid, a trace of which can sometimes, but not always, be found. They effervesce with acids, and of course dissolve in water, but not with extreme readiness, that is to say, not like a deliquescent salt.

I need hardly remark, how thoroughly any one working with liquor potassæ might be deceived if he were not aware of these facts.

2. Every one knows that acetate of potash is a very deliquescent salt, and that, when it is formed under the microscope, it generally soon disappears. But acetate of potash, forming by the union of its constituents, and crystallizing out of acetic acid, is (as long as acid is present) a stable salt, which has a crystalline form, widely differing from acetate of potash crystallizing out of water. And (a most remarkable circumstance) the form of the acetate of potash varies according to the strength of the acid out of which it crystallizes, so that there is a great range of phenomena, which might tend to mislead even a very careful observer. As the crystals forming in liquor potassæ often resemble cystine, so the acetate of potash, forming out of strong acid, resembles, to a certain extent, some form of uric acid. For, mixed up with other forms, long dagger-like or lancet-shaped crystals are seen, which, if we were on the *qui vive* for uric acid, might very well deceive us. I need not say how frequently in micro-chemical research these two common re-agents may meet on one slip of glass.

3. The re-action of iodine again is a most important one. The rule is, that iodine colours starch blue; but in certain albuminous mixtures, as pointed out lately by Majendie at the College of France, iodine loses this property, and, as far as starch is concerned, is temporarily indetectible. This difficulty must be done away with before iodine can be used without fear in micro-chemistry.

4. One more singular instance of modification of properties from admixture may be mentioned. Acetate of potash and chloride of calcium are separately highly deliquescent salts. Mix together acetic acid, liquor potassæ, and chloride of calcium, so as to have some slight excess of acetic acid, the mixture will evaporate to a solid, dry, crystalline mass. Now, in complex fluids, such as blood, exudations, and even in urine, these four re-agents may very easily occur together under the microscope, and the resulting crystals may mislead. I do not know that a mistake from this cause has ever actually arisen, but its possibility is evident.

I might narrate various other curious re-actions, had I time or did your space permit. Enough has been said to show that in micro-chemistry we require a thorough examination of the behaviour of our re-agents among themselves, before we bring them into play on other bodies. Such an examination I should hope some of your young energetic readers will take up, and it is for the purpose of inciting some one to do so that I have written this letter. It is evident also that not only micro-chemistry will benefit by this inquiry, but that crystallography may thus be studied under (as far as I know) a different aspect, and that not only the microscopist, but even the chemist may acquire, from the phenomena of crystallization under unusual circumstances, some increase of the present knowledge of physical and chemical re-actions.—E. A. Parkes, M.D., *Harley Street, Cavendish Square.*

On Thin Glass-Covers.—Most persons who have treated themselves to the luxury of a microscopic object-glass of large aperture and high power, have experienced the disappointment of finding that some pet object, whose structure they expected to see finely developed, has been permanently mounted under a cover so thick as to put vision with such a glass entirely out of the question.

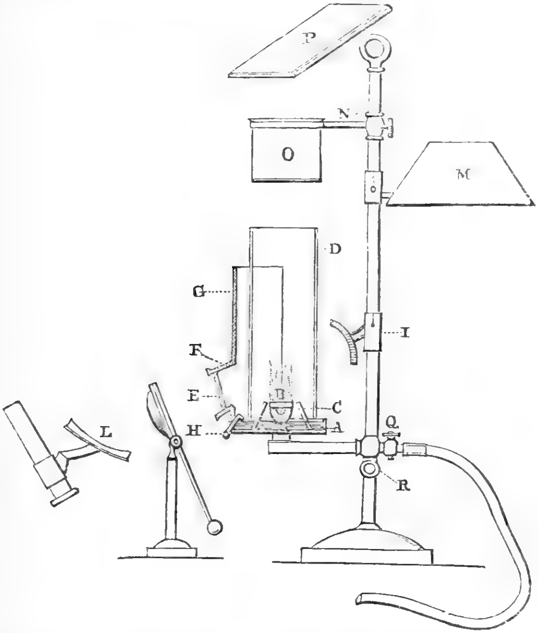
The reason of this is, not that very thin glass cannot be procured, or that it is particularly expensive (for the increased quantity of the thinner material contained in the same weight fully compensates for the increased price), but that the delicate manipulation required in cutting and cleaning it induces those who mount objects for sale, as well as most others, to prefer a glass of greater thickness.

It is desirable that no object which may require to be submitted to a higher power than a quarter-inch object-glass of 75° aperture should ever be mounted under a cover thicker than 1-140th (,007) of an inch. Indeed, if the aperture of the object-glass exceeds 120°, the best thickness for the cover is 1-250th (,004) of an inch. Glass of this thickness can easily be cut with a good writing diamond when laid on a piece of plate-glass, as proposed by Mr. Warington, and described in Mr. Quekett's Treatise on the Microscope, second edition, p. 265; but in the cleaning, a great many pieces are usually broken. The following method, which is often used by chemists for cleansing test-tubes, &c., I have found to succeed:—Place the covers in a small cup or glass, and pour over them enough strong sulphuric acid (common oil of vitriol) to wet every part of them. Let them stand for a day or two; then wash them in repeated waters until all the acid is removed. Stretch a clean cambric handkerchief tight over any flat surface, such as a piece of plate-glass or a druggist's pill-slab, and lay the glasses on it a few at a time. By rubbing them very gently with another handkerchief on the finger, they may be dried without using sufficient force to break them. They should then be removed to a clean box with forceps, and carefully kept from dust, and from contact with the fingers. Before, however, they have undergone this careful cleansing, the covers should be sorted according to their thickness, the readiest method of doing which is by means of an instrument made by Mr. Ross, called a "lever of contact." It consists of a long, slender index, having a projecting touch near the centre of motion, which is kept in contact with a plane surface by means of a spring. When a piece of glass is inserted under the touch, the index points to the thickness on a graduated arc. In this way covers may be sorted very rapidly.

The same thing may be accomplished less readily by merely placing a fragment in the pliers, with the edge upwards, under the microscope, armed with an inch object-glass and an eye-piece micrometer, and measuring its thickness in the usual way.

When an object is already mounted, neither of these methods is applicable; but the thickness of the covering-glass may then be ascertained very nearly by having the head of the fine adjusting screw graduated, and ascertaining the value of the graduations on a piece of glass previously measured by either of the former methods. For example, the screw-head in my microscope is divided into ten; and to focus from the lower to the upper surface of a piece of glass 1-100th of an inch thick, takes one turn and six-tenths, or 16 divisions; consequently, it would take 1600 divisions to focus through an inch of *similar* glass. Therefore, if I divide 1600 by the number of divisions through which the screw has been moved, I shall obtain the thickness in the vulgar fraction of an inch, or the decimal expression of the same quantity by dividing the number of divisions by 1600. Unless the glass has been carefully wiped, some specks will be readily found by which to adjust the focus.—GEORGE JACKSON, *Church Street, Spitalfields.*

Achromatic Gas-Lamp for the Microscope.—Gas as a source of light presents great advantages over oil and spirit, on account of cleanliness, being ever ready for use, and affording a perfect control over the flame; but when the ordinary gas-lamps are used for the purpose of illuminating the field of the microscope a yellow glaring light is given, alike injurious to the eye and the definition of the object under examination. To correct these evils, I have arranged a lamp which is also otherwise useful to the microscopist. It consists of a stage, A, supported by a tube and socket, sliding on an upright rod rising from the stand. This carries an Argand burner, B; a metal cone, C, rises to the level of the burner, and is about one-eighth of an inch from its outer margin.



This arrangement gives a bright *cylindrical* flame. The bottom of the stage, B, is covered with wire gauze, to cut off irregular currents of air, and thus secures a *steady flame.* Over the burner is placed a Leblond's blue glass chimney, D. This corrects the colour of the flame to a certain extent; but it is still further rectified by a disc of bluish black neutral tint glass, E, fitted in a tube, F, attached obliquely to the shield, G. G is a half cylinder of metal, which serves to shield the eyes from all extraneous light, but may be rotated on the stage, A, by aid of the ivory knob, H, when the full light from the flame is desired. A metallic reflector, I, fixed on its support, so as to be parallel to E, concentrates the light. By the combination of the two glasses, D and E, the yellow rays of the flame are absorbed, and the arrangement affords a soft white light which may be still further improved by receiving the rays on a concave mirror, backed with plaster of Paris, L; and where a very strong light is required, a condensing lens should be interposed between the lamp and the mirror of the microscope. By removing the shield, G, and bringing the shade, M, over the burner, it may be used as a reading-lamp. A retort ring, N, supports a water-bath, O, or a wrought-iron plate, P, 6 inches by 2½ inches, both used in mounting objects. The stop-cock, Q, gives the means of regulating the flame. The screw, R, clamps the lamp-head at any height desired. The lamp may be attached to any gas supply, by vulcanized India-rubber tubing.

This lamp might be used for many other purposes, as for minute dissections, watchmaking, engraving, &c. A Leblond's chimney, in combination with an outer glass globe of a bluish black neutral tint, might be with advantage used in our dwellings.—SAMUEL HIGHLEY, Jun., 32, *Fleet Street.*

Gold-Dust under the Microscope.—Mr. Warren De la Rue has sent us some specimens of African gold dust, mounted for microscopic examination by Mr. James Nasmyth, of Patricroft, Manchester. Under an inch object-glass they present an interesting object. Each grain has the irregular, smooth, worn surface that is so characteristic of the larger nuggets, and whilst looking at them, as Mr. Nasmyth observes, one is almost tempted "to put out the hand and grab one or two from so rich a field." The examination proves that the same causes have been at work in producing the smaller grain which have acted upon the large nuggets.

Infusoria in morbid discharges.—At one of the weekly meetings of the London Medical Society, Mr. Weedon Cooke exhibited some purulent discharge from a cancerous tongue, which presented a large number of Infusoria. They were of two kinds, apparently belonging to the families of Monadinæ and Vibriones. Mr. Cooke stated he had not seen animalcules in cancerous discharges from other parts. Infusoria are not uncommon in diseased secretions from the mouth and in the decomposing food that collects about the teeth, and it is probable these animalcules were not specially connected with the diseased product in which they were found.

Red Animalcules in food.—M. Montagne, in a letter to M. Flourens, which was read before the Academy of Sciences in Paris, gives an account of the occurrence of the *Monas prodigiosa* of Ehrenberg, in various kinds of food, in a district near Rouen in France, in July last. Pastry, fruit, vegetables, and other articles of food suddenly exhibited an intense carmine or bright rose colour, which was found to depend on a gelatinous substance, which, when examined under the microscope, presented the appearances of the animalcule described by Ehrenberg. M. Montagne says he has succeeded in propagating this animalcule by means of boiled rice.

On the Occurrence of Nucleolated red Corpuscles in Human Blood.—In the examination of some human blood, made for the purpose more especially of observing the changes in form occasionally assumed by the Protean colourless or lymph corpuscles, I was fortunate enough to meet with a very distinct and clearly defined nucleolated red corpuscle, to employ the term used by Mr. Wharton Jones in his very valuable Memoir on the Blood in the 'Philosophical Transactions' (1845). This form of corpuscle, though stated by Mr. W. Jones to be common in the blood of the horse and elephant, appears to have occurred to his observation but once, and then doubtfully, in that of man. The observation now recorded, therefore, of what must be regarded as a rare phenomenon, and which was confirmed at the time by my friend Mr. Huxley, may be considered of some interest and of importance, towards the confirmation of Mr. W. Jones's views respecting the nature of the blood corpuscle. The nuclear portion of the corpuscle in question was rather smaller than most of the free blood discs, but not so small as some of them, nor apparently much, if at all, below the mean size of those bodies. It is to be regretted, that on my proceeding to take its dimensions with greater accuracy than by mere comparison with the surrounding blood discs, the object was lost. No others of a similar kind could be detected on prolonged examination of the same blood, which, it may be observed, was taken about an hour after his breakfast from a young and vigorous man. The observation was made on the 4th December.—George Busk.

The Polygastrica larval states of Worms.—In the May number of 'Silliman's Journal' there is a letter from Professor Agassiz to Mr. Dana, in which he makes the following remarks:—"You may remember a paper I read at the meeting at Cambridge (America), in August, 1849, in which I showed that the embryo which is hatched from the egg of a *Planaria* is a genuine polygastric animalcule of the genus *Paramecium* as now characterised by Ehrenberg. In Steenstrup's work on alternate generation* you find that in the extraordinary succession of alternate generations ending with the production of *Cercaria* and its metamorphosis into *Distoma* a link was wanting—the knowledge of the young hatched from the egg of *Distoma*. The deficiency I can now fill. It is another Infusorium—a genuine *Opalina*. With such facts before us

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* Translated by the Ray Society.

there is no longer any doubt left respecting the character of all these Polygastrica: they are the earliest larval condition of worms. And since I have ascertained that the Vorticellæ are true Bryozoa, and botanists claim the Anentera as Algæ, there is not a single type of these microscopic beings left which hereafter can be considered as a class by itself in the animal kingdom."

Ear-Wax.—Most persons are familiar with the fact that the wax occasionally accumulates in the external auditory passage to such an extent as to produce partial deafness. I was under the impression that the pellet usually found was actually ceruminous, until very recently, when an opportunity was afforded me of examining a small accumulation microscopically. I found it to be composed entirely of a *mucedinous fungus* and a minute portion of epithelium. On maceration in ether and subsequent evaporation, I could find no evidence whatever of the existence of wax. I shall be glad to know whether other observers have noticed the same fact. If so, it is interesting as explaining the comparative rarity of the accumulation, and in general its small liability to return.—T. INMAN, M.D., Liverpool.

Microscopical Inquiries.—Will you kindly inform me in your forthcoming number what kind of camera is best for drawing from the microscope; and whether any particular description of photographic paper is better suited than another for the same purpose?

I think that photographic pictures of microscopic objects would be exceedingly valuable, as we should not then be liable to error in our representations of what we see, in consequence of any preconceived notions of the subject, which I think is at present the case to some extent.—J. I.

[We shall be glad to insert queries such as the above, and to receive answers from our correspondents. We are not clear whether our correspondent inquires about a camera for ordinary drawing or for photography.—EDS.]

PROCEEDINGS OF SOCIETIES.

Microscopical Society of London. 1852.

October 27.—George Busk, Esq., in the Chair. A paper by Joseph Delves, Esq., "On the Application of Photography to the Representation of Microscopic Objects," was read. After some preliminary observations the author proceeded to describe his method by stating, that the only arrangement necessary for the purposes of Photography is the addition to the microscope of a dark chamber, similar to that of the camera obscura, having at one end an aperture for the insertion of the eyepiece and of the compound body, and at the other a groove for carrying the ground glass plate. This dark chamber should not exceed 18 inches in length, as if longer the light transmitted by the object glass is diffused over too large a surface, and the picture is faint and unsatisfactory. Another advantage is, that pictures taken at this distance are in size very nearly equal to the object as seen in the microscope. The time of producing the pictures varies from five to fifteen seconds.

He also made some remarks upon the mode of manipulating, and concluded by calling attention to some very beautiful specimens, which were exhibited, and afterwards presented to the Society.

November 24.—George Jackson, Esq., in the Chair. Messrs. Redwood, Brown, Osborne, Ludlow, and Tischmacher were elected members. A Paper was read by R. Hodgson, Esq., "On the Reproduction and Delineation of Microscopic Forms." The object of the Paper was to point out the value of the camera lucida for delineating microscopic forms as compared with the various photographic processes. In the discussion which followed the reading of this Paper, Mr. De la Rue, Mr. Bowerbank, and Mr. Hogg expressed their conviction, that by photography more accurate and more available pictures of microscopic objects would one day be made than could be done by the hand. Mr. Shadbolt exhibited a very accurate photograph, which he had succeeded in obtaining by means of a camphine lamp. From this he thought that persons who had not time to work at photography by day and natural light, would be able to accomplish this object at night by artificial light.

December 29.—George Jackson, Esq., in the chair. A paper was read by Mr. Busk on the Starch Granule, in which he showed, in accordance with the views of Leeuwenhoek and Martens, that its structure was vesicular. The granules were examined under the action of heat, sulphuric acid, and other reagents. Mr. Brook exhibited a moveable arm for changing object-glasses without a screw, and a portable stand for examining objects with a pocket-glass.

Pathological Society.

At the meeting in November, Dr. Richard Quain brought forward two cases of Leucocythemia. The first was the case of a man thirty-seven years old, who had enlargement of the spleen and liver, also of the glands of the neck and axilla, and other parts of the body. The white cells in the blood were very numerous, and contained nuclei. The second case was that of a woman, forty-five years of age, who also had enlargement of the liver and spleen.

OBITUARY.

In Dr. Algernon Mantell, who died on the 10th of November, the science of microscopy has lost a most ardent cultivator. He early perceived the value of the microscope as an instrument of geological research, and many of his papers indicate how successfully he used this instrument. One of his works, entitled 'Thoughts on Animalcules,' was devoted to a subject entirely microscopical, and displays an intimate knowledge of the structure and habits of many of the recent species of Infusoria. As a scientific teacher and cultivator of geology and its kindred sciences, Dr. Mantell's loss will be severely felt.

DESCRIPTION OF PLATE II.

On the Embryogeny of Orchis mascula, *by Dr. Cobbold.*

The letters indicate the same in all the figures :—*b*, bract ; *p*, peduncle ; *ov*, ovula ; *n*, nucleus ; *se*, secundine ; *pr*, primine ; *pt*, pollen tube ; *es*, embryo-sac ; *ev*, embryonic vesicles.

Fig.

1. Flower of *Orchis mascula* prior to impregnation.

2. 3. 4. 5. Stages of growth of ovula before the period of fertilization (mag. 200 diamet.).

6. Condition of the ovarium and peduncle at the time of impregnation.

7. Portion of the same (mag. 2½ diamet.).

8. Fully developed ovule (mag. 200 diamet.).

9. 10. 11. Mode of union between the pollen tube and embryo sac (figs. 9 and 10 mag. 250 diamet.).

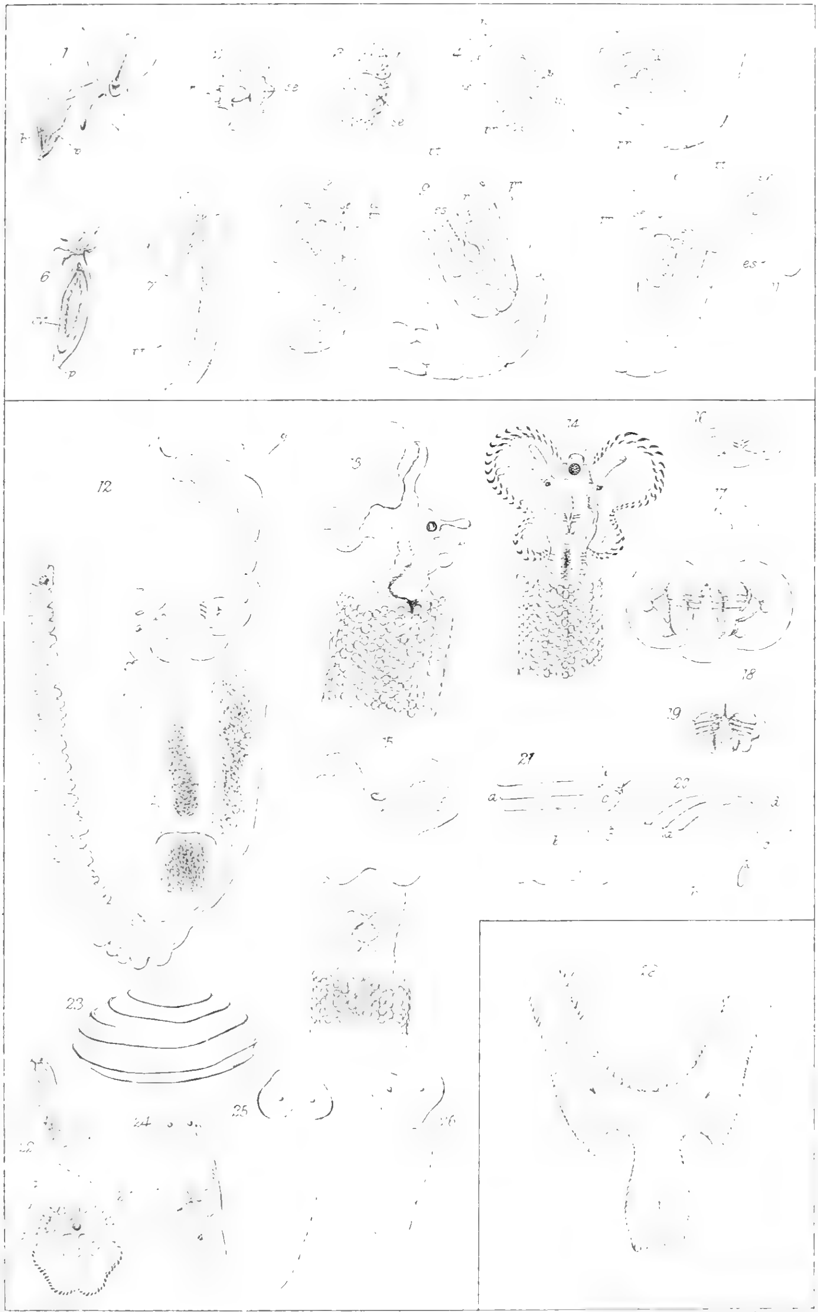
On Melicerta ringens, *by P. H. Gosse, Esq.*

Figs. 12 to 27.—Details of the Anatomy and Development of *Melicerta ringens*.

12. The animal extracted from its tube viewed sidewise.
13. The animal within its tube, expanded (the lower half omitted).
14. The same viewed in front ; ventral aspect.
15. The same ; dorsal aspect.
16. The gizzard, *in situ.*
17. One jaw.
18. The gizzard under pressure.
19. The jaws under pressure.
20. 21. One jaw, as *in situ* and under pressure ; the parts lettered alike, for comparison.
22. A peculiar gland in the foot.
23. A ridged egg.
24. A smooth egg.
25. The young newly hatched ; ventral aspect.
26. The same, dorsal aspect.
27. The same, commencing its tube ; vertical aspect.

On Melicerta ringens, *by Professor Williamson.*

28. Mouth of Melicerta, showing the continuity of the lower ciliated ridge, with the arches at the side of the mouth.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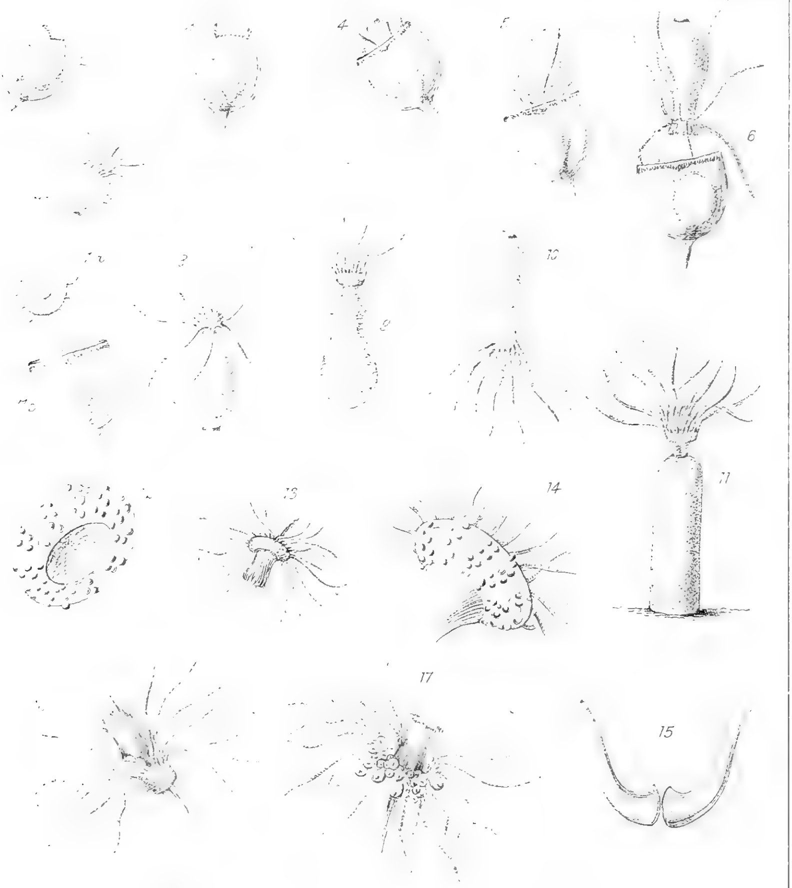

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DESCRIPTION OF PLATE IV.

On a Cyst upon the Olfactory Nerve of a Horse, *by J. B. Simonds, Esq.*

Fig.

1. The cyst containing a crystal of oxalate of lime.—*a*, Bell-shaped spot in interior of cyst.—*b*, A moveable mass of granular matter.

On the Development of Tubularia indivisa, *by J. R. Mummery, Esq.*

16, 17. Fully developed head of *Tubularia indivisa*, loaded with reproductive capsules.

13. Newly-formed head.

14. The same, showing arrangement of ovaries.

12. Internal surface of head (the oral tentacles removed), exhibiting twelve lines radiating from base of cavity, and corresponding with external ovaries.

15. Base of two marginal tentacles.

18. A group of reproductive capsules from the full-grown head, in several co-existing stages of development.

2, 3, 4, 5, 6. Progress in the extrication of young *Tubularia*, at intervals of one hour.

8. A young animal of the ellipsoidal form.

7A. Ditto, of the discoidal variety.

7B. The same, thirty-six hours after emerging from the capsule.

7C. The empty capsule.

10. The specimen, fig. 8—three days after—still free.

9. Ditto, on the fifth day, having affixed itself at base.

11. The young animal at the expiration of six weeks ; the head having now acquired a pale rose tint, and the peripheral tentacles increased to sixteen.

DESCRIPTION OF PLATE V.

On the Structure and Development of Volvox globator, *by Geo. Busk, Esq.*

1. Embryo *Volvox*, in which the contents are divided into four segments.
2. Ditto, in which segmentation has proceeded to the formation of numerous segments, each furnished with several amylaceous spherules.
3. Ditto, after segmentation is completed, but before the appearance of cilia.

3.* Portion of the edge of an embryo *Volvox* viewed in the equatorial plane, showing the cilia perforating the outer tunic, but not passing beyond the external gelatinous (?) envelope.

4. The same when tested by solution of iodine.
5. Portion of the edge of mature *Volvox* (var. *vulgaris*) viewed in the equatorial plane and representing three zoospores *in situ*. The faint lines between indicate the limits of the gelatinous envelope of each zoospore, the junctions of which are indicated by the hexagonal areas of Mr. Williamson. (These intermediate lines have been added to the figure since the original production of the paper.)
6. Mature zoospores, undergoing "deliquescence."
7. Zoospores in which the contractile vacuole is still present.
8. "Winter spores" of *V. aureus*. *a*, in the earlier state; *b*, when matured.
9. Contents of mature winter spore, affected by solution of iodine. *a*, amylaceous granules; *b*, yellow oil.
10. More highly magnified view of a winter spore compressed, to show the double tunic.
11. The same crushed, and treated with iodine and sulphuric acid.
12. A portion of the edge, to show the granular fluid (as rendered so by iodine) between the outer and inner tunics. *a*, granular fluid; *b*, interior of spore.
13. Portion of wall of *Sphærosira Volvox*.
14. Zoospores in different stages of development. *a*, one fully divided, seen on the side; *b*, the same viewed from above; *c*, one in which segmentation has proceeded only to the second division.

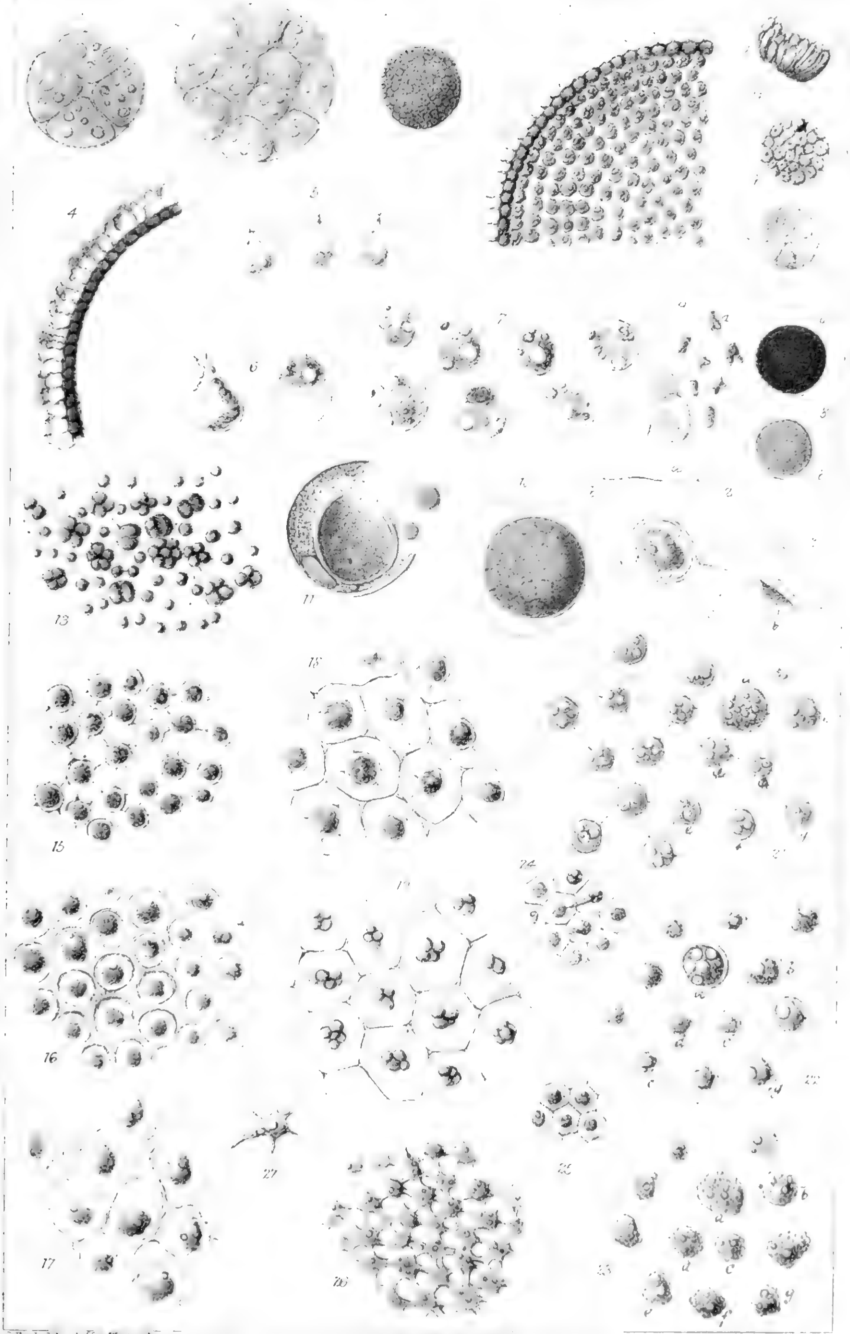
15.
16.
17. } Series of changes occurring in the hydropical condition of zoospores.
18.
19.

20. More highly magnified view of the same—where there is apparently a second coat in process of being thrown off from the central mass of protoplasm.

21.
22. } A series of changes undergone by the same zoospores in the course of twenty-four hours.
23.

Fig. 22 shows the partial dropsy of the cell, but which did not proceed further.

24. Professor Williamson's hexagonal areolation.
25. Ditto under iodine.
26. Appearance assumed by the zoospores in the early state, where, owing to abundant nutrition, the quantity of protoplasm is very abundant. This form gradually passes into the ordinary, and it is in this state that the contractile spaces are most advantageously to be sought.
27. Shows the situation of the contractile vacuole in a connecting band.



G. Busk, del. Tuffen West, lith.

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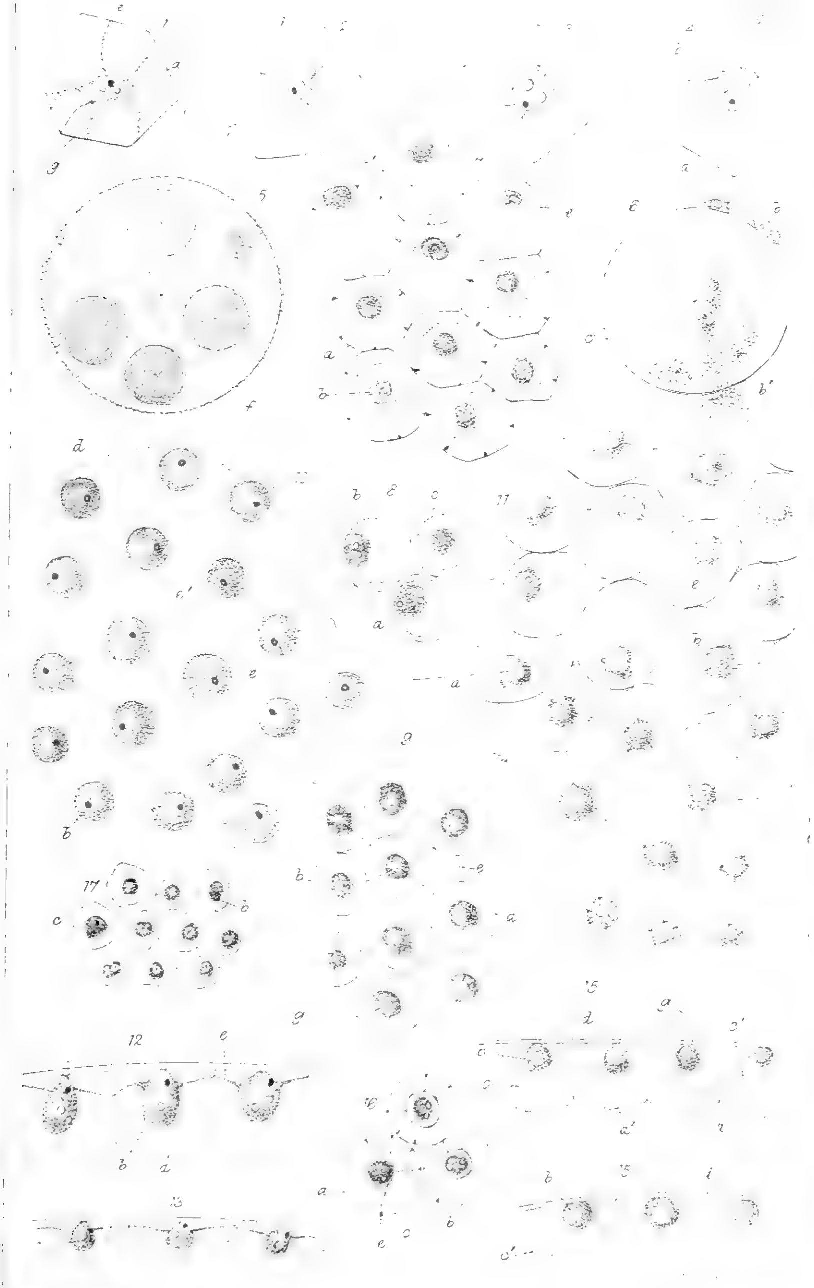

W.C.W. del. Tuffen West sculp.

Ford & West Imp. 54 Hatton Garden

DESCRIPTION OF PLATE VI.

On the Structure of Volvox globator, *by Professor W. C. Williamson.*

The same letters of reference are employed throughout to indicate the same structures.

1. 2. 3. 4. Cells of the *stellate var.* of *Volvox* in different stages of the contraction of the protoplasmic threads. *a*, outer cell-wall; *b*, protoplasm; *e*, connecting threads; *g*, cilia.

5. Section of *Volvox*, with its ciliated parietal cells. *f*, vesicles in which the ciliated gemmæ are developed. Two of the gemmæ seen out of focus.

6. Young gemma ruptured by pressure. *b*, detached protoplasms; *f*, vesicles within which the gemma is developed; *c*, protoplasmic membranes of three segments of the gemma. *b*, granular and mucilaginous matter escaping from the ruptured segments.

7. Portion of a *Volvox* mounted in glycerine and viewed obliquely. *a*, cell-walls; *b*, protoplasms; *c c*, protoplasmic membranes; *e*, collapsed connecting threads.

8. Similar cells, in which the protoplasmic membrane is more distended. References as before.

9. Specimen in which the threads *appear* to traverse the intercellular spaces. References as before.

10. Ordinary appearance of the var., with spherical protoplasms.

11. Specimen of the same mounted in glycerine.

12. Probable section of living *Volvox*. *d*, superficial pellicle.

13. Probable section of fig. 11.

14. 15. Sections of figs. 1-4, after being mounted in glycerine.

16. Detached cells from the same, viewed superficially.

17. Similar specimen, in which the cells are invisible—the protoplasmic membranes alone being seen.

ORIGINAL COMMUNICATIONS.

On the Development of the Teeth, and on the Nature and Import of Nasmyth's "Persistent Capsule." By THOMAS H. HUXLEY, F.R.S.

I AM desirous of setting forth in the course of the following pages, as concisely as may be, the principal results to which I have been lately led in the course of working over the development of the human and of some other teeth. I have directed my investigations, not to the general phenomena of dentition, our knowledge of the course of which, firmly established many years ago by Professor Goodsir, has not been affected, so far as I am aware, by any subsequent investigations, but to those points of structure and development upon which every writer, from the time of John Hunter to the present, seems to have formed, with more or less plausibility, an opinion of his own, different from that of all others.

I must suppose such a knowledge of the general course of development of the teeth as may be found in the ordinary hand-books of physiology—my limits allowing no unnecessary disquisition—and proceed at once to the questions whose discussion I am about to attempt. These are, firstly: What are the three structures which are concerned in the development of the teeth, viz., the pulp, the capsule, and the enamel organ, *morphologically*, or in relation to the parts of the mucous membrane from which they are developed?

Secondly: What is the relation of the dentine, the enamel, and the cement, to these organs?

Thirdly: What is the relation of the histological elements which enter into the composition of the soft parts, to the dentine, enamel, and cement, which are formed from, or within them.

These questions, I think, involve all the essential points connected with the teeth. Having endeavoured to answer them, I shall inquire with what other organs of the animal the teeth correspond.

1. *The nature of the pulp, the capsule, and the enamel organ, with relation to the mucous membrane from which they are developed.*

The teeth are developed in two ways, which are, however, mere varieties of the same mode in the animal kingdom.* In the first, which may be typified by the Mackerel and the Frog, the pulp is never free, but from the first is included within the capsule, seeming to sink down as fast as it grows.

In the other the pulp projects freely at one period above the surface of the mucous membrane, becoming subsequently included within a capsule formed by the involution of the latter: a marked instance of this mode of development occurs in the human subject. The Skate offers a sort of intermediate stage.

If the thick and opaque, coloured, mucous membrane of the jaw of the Mackerel be torn away, and the alveolar edge of the jaw be then examined with a low power, minute germs will be seen to be imbedded in the substance of the jaw, among the large, fully-formed teeth. One of the smallest of those which I examined is figured at Pl. III., fig. 10. It was an oval mass, about 1-60th of an inch in long diameter; its upper part was roofed as it were by the epithelium of the gum; its sides were constituted by a continuation of the basement membrane of the mucous membrane of the mouth; within this was a homogeneous substance, containing numerous oval or rounded nuclei, about 1-5000th of an inch in diameter, and continuous with the lowest layer of the epithelium of the mouth. In the centre appeared a large conical mass, nearly as long as the sac, the proper tooth pulp. Pointed above, it widened below, and then gradually contracted again, so as to form an almost hemispherical lower extremity, which was united to the base of the sac by a narrow neck. In the upper part of the papilla the proper dental tissues had already begun to make their appearance; but below, a delicate membrane formed its outer boundary, and this passed directly into the basement membrane of the sac.

It is clear then, that in this case the papilla is wholly a process of the derm (or that which in a mucous membrane corresponds to it) outwards, while the sac is a process inwards of the same structure; and that the homogeneous substance, with its imbedded nuclei between the two, corresponds with the epidermis or epithelium.

In the Frog the same relations essentially hold good; the young teeth are here developed in minute sacs, which lie at the bottom of the dental groove in the upper jaw. I could never detect any free-projecting pulps (nothing, therefore,

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* For the purposes of the present examination I have taken the Skate, the Mackerel, the Frog, the Calf, and Man, as accessible specimens of each of the great divisions of animals possessing teeth.

corresponding to the papillary stage in the human tooth), but the smallest and youngest rudiments of the teeth I found were oval or rounded sacs, 1-180th of an inch long, containing an oval papilla, about one-fourth shorter. Externally, these were bounded by a strong structureless basement membrane, which enclosed a homogeneous substance, containing nuclei in its cavities. These were rounded, and very close together, next to the basement membrane, but became transversely elongated in the inner layers and next to the pulp. This last was bounded by a structureless membrane, which at its narrow base became continuous with the basement membrane of the capsule.

In the Frog, then, the relations of the pulp and of the capsule are the same as in the Mackerel.

In the Skate, as is well known,* the young teeth are developed in longitudinal rows within a deep fold of the mucous membrane of the mouth, behind the jaw. So far as my examinations go, however, I find that this is not a mere simple fold, such as it has been described to be ; but its two walls behave just in the same manner as those of the primitive dental groove in man—that is, they become closely united in lines perpendicular to the direction of the jaw, so that partitions are formed between every two rows of teeth—transverse partitions again stretch between the separate teeth of each row, but these did not appear to me to be complete, terminating by an arcuated border below (*fig.* 11). Each longitudinal canal therefore answers to a single elongated mammalian follicle, or to that prolongation of the alveolar groove from which the posterior permanent molars are formed in man (*see* Goodsir), only the process does not go so far as in this case, the separate capsules remaining imperfect anteriorly and posteriorly. The lateral walls of the capsule, however, seem to me to have as much (or as little) "organic connexion with the pulp and attachment to its base" as in man, and the process seems to correspond with something more than the "first and transitory papillary stage of the development of the mammalian teeth." †

Each pulp is invested by a very distinct basement membrane, whose continuity with that of the mucous membrane of the follicle is very obvious. The epithelium of the follicle forms a thick layer, which sometimes, when the upper wall is stripped back, adheres to it—sometimes remains as a cap

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* See Blake's 'Essay,' &c. 1801, in which the essential peculiarities of the development of the teeth in the shark and skate, and their mode of advance, are very well pointed out. He refers to Herissant and Spallanzani as having anticipated him.

† See Owen's 'Odontography,' p. 15.

investing the papilla. Even when the latter does not take place, shreds of the epithelium frequently adhere to the papilla in the form of irregular, more or less cylindrical nucleated cells; as often, however, the papilla, whether any of the proper tooth substances be formed or not, has nothing adherent to it, but presents a perfectly smooth sharp edge. Other portions of the epithelium, particularly towards the bottom of the follicles, are more or less altered and irregular, *frequently assuming the form of a stellate* tissue.

In the Skate, then, the follicle is an involution of the derm, the papilla is a process of it, and the epithelium between the two becomes metamorphosed sometimes into a peculiar stellate tissue. The same essential relations prevail as before.

In Man, some confusion has prevailed with regard to the homology of the various component parts of the tooth sac, though they might be readily enough deduced from the mode of development of the sac; however, it is, I think, not at all difficult to obtain perfect demonstration upon this subject.

If a young tooth capsule be opened (say of a fœtus at the seventh month), whatever care may be exercised, it will always be found (Hunter, Bichât) that a space filled with a fluid exists between the inner surface of the capsule and the outer surface of the pulp—*the two are perfectly free from all adherence to one another*—the only substance between them, besides the fluid, being a more or less abundant whitish matter which sometimes adheres to the one and sometimes to the other (*see* Goodsir, *l. c.*).

If the tooth be very young, a structureless membrane, the m. preformativa of Raschkow (the basement membrane of Bowman), may be traced over the whole surface of the pulp, or if calcific deposition have already commenced, it may be found readily enough at any rate in the lower unossified part; and it is not at all difficult to trace this in perfect continuity on the walls of the capsule—in fact into its basement membrane. The best way of seeing this is by detaching the whole sac from its alveolus, and then, laying it carefully open in a watch-glass, turn the capsule carefully back, transfer the whole to a glass plate, and cover it with a piece of thin glass. The continuity of the basement membrane of the pulp with that of the capsule is now evident enough under the microscope.

The wall of the capsule is often folded, and sometimes I have noticed villous processes, such as those described as vascular by Dr. Sharpey.* Not unfrequently the basement

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* See also Goodsir, *l. c.* p. 17. In a child at birth "the interior of the sac had a villous, highly vascular appearance, like a portion of

membrane of the capsule is quite naked, but I have sometimes observed a lining of short cylindrical nucleated epithelium cells upon it.

I have said that a whitish substance lies between the basement membrane of the pulp and that of the capsule. It is delicate and friable, but frequently forms a more resisting layer towards the pulp. On this surface I have found it to be composed of a layer of elongated, more or less cylindrical epithelium cells 1-1000th of an inch in length, with or without nuclei, and adhering together in the direction of their short diameters. On the surface towards the capsule, on the other hand, this substance is composed of irregular cells united into a network (*fig.* 7), and very similar to those which have been described in the Skate. The structure of this substance, and its relation to the basement membrane of the pulp, and of the capsule, clearly indicate that it is nothing more than the altered epithelium of these organs.* It is the so-called "*enamel organ*" of authors, and very wonderful figures and descriptions indeed have been given of it in various works upon the teeth. The only detailed,† and at the same time, as it seems to me, completely accurate account I have met with of this so-called enamel organ, is the very clear and admirable description by Mr. Nasmyth, contained in his posthumous work, '*Researches on the Development, Structure, and Diseases of the Teeth,*' 1849. The merits of this gentleman have met with such scant justice that I cannot do better than let them speak for themselves in this place; those who work over the subject hereafter will not fail, I think, to acknowledge them as I have done.

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injected intestinal mucous membrane." See also p. 25 of the same admirable essay.

* Goodsir ('Edin. Med. and Phys. Journal,' 1839) and Todd and Bowman ('Physiological Anatomy') state very distinctly that the pulp is an ordinary papilla, and the capsule an involution of the mucous membrane, and the latter justly described the membrana preformativa of the pulp as a basement membrane (p. 175), but they consider the "stellate tissue" and the enamel organ to be the "wall of the sac itself." Kölliker ('Mikr. Anat.,' p. 101) expresses the same opinion.

† Mr. Tomes ('Lectures,' &c., 1848) appears to me to have described the enamel organ very accurately, but he has, I think, failed to distinguish the proper enamel organ or epithelium of the sac from the submucous cellular tissue—the latter is his "reticular stage of the enamel pulp," the former his "second stage" or "stellate tissue," while what he calls the "transition part," p. 99, is, I think, the dense superficial layer of the capsule, very well described by Mr. Nasmyth (*vide infra*) as "the internal lamina of the dental capsule."

Professor Kölliker ('Mikr. Anat.,' p. 99 B) appears to me to have fallen into the same error.

Development of the Formative Organs of the Teeth, Follicular stage.— " At an early period of the follicular stage when the apex of the papilla rises above the level of the surrounding fence of mucous membrane, a small quantity of whitish matter may be detected in the groove between the papilla and the follicle—this is the *enamel organ.* Not unfrequently the whitish matter has the appearance of granules which seem to have been separated from the surface of the follicle. These granular masses have a pearl white aspect, and are soft and friable. Under the microscope they are seen to be composed of cells which separate from one another upon the slightest compression. The cells offer considerable variety in respect of size and shape, some being small and round, others large and flattened, and furnished at one extremity with a delicate prolongation ; while others again are elongated and narrow, and have a defined and regular margin. They contain nuclei and nucleoli, and are covered on their interior by minute granules, which are also found in considerable abundance in their interstices."—p. 104.

" In the numerous examinations which I have made of the stages of growth of the teeth here described, the enamel organs did not appear to me to be attached either to the papilla or to the surface of the follicle. This may probably arise from the circumstance that all the embryos which I dissected had been kept for some time in diluted spirits of wine." —p. 105.

He then quotes Raschkow's account of the structure in the Lamb and Calf, and goes on to say,—

" In my own investigations made with the aid of one of the best microscopes of modern construction, and with a magnifying power of one-tenth of an inch focal distance, I found the enamel substance to be composed of cells of three different kinds.

" The first kind of cells are found in the interior of the organ, and compose its loose, soft, and easily compressible texture. They are flattened and triangular in form, and connected to adjacent cells by means of delicate filaments prolonged from one of their angles. These appendages have no analogy with the filaments of areolo-fibrous tissue, as declared by Raschkow. I have seen them in connexion with the cells of other tissues, and the error on the part of this observer must have arisen from the use of low microscopic powers.

" The second kind of cells are oval in shape, and form an envelope to the preceding : they are situated both upon the superficial and deep aspect of the latter.

" The third kind of cells occupy the deep stratum of the enamel organ, lying in contact with the dental papilla. They are narrow and oblong in shape, and are arranged closely side by side ; one of their extremities being in relation with the papilla, the other being directed outwards. They are firmly connected together, and have a radiated position in respect of the papilla. It is to the layer formed by these cells that Raschkow has assigned the name of enamel membrane. Taking this view of the construction of the enamel organ, I cannot perceive any grounds for the division of it into two parts suggested by the description of Raschkow. It is obviously nothing more than a single organ, and the difference in the form and arrangement of the cells must simply be regarded as a transition of the first and second kinds into those of the third—the latter being in the state of preparation for the reception of the calcareous salts.

" The mucous membrane which rises in the form of a ring fence around the papilla developed from the dental groove is the future *dental capsule.* At an early period it is difficult to determine to what extent the internal surface of the growing follicle differs from mucous membrane. That it does so may be inferred from the change in function which it assumes; and at a later period, when the follicle is about to close, the difference in its organic character becomes strikingly obvious. For example, it is white, silvery, loose, and rugous, and easily falls into folds, and, under the microscope, offers the appearance of a number of minute cells possessing characters widely different from those of the epithelium.

"A portion of the internal lamina of the dental capsule, placed under the microscope, shows it to be composed of layers of cells loosely arranged, and separated by interspaces equal to half the diameter of the cell. The cells are oval in shape, and provided with one or more distinct nuclei, and they contain in their interior a small quantity of granular matter. The internal lamina of the dental capsule maintains but a slight degree of adhesion with the enamel organ, and possesses no vessels. Subjacent to it is a network of blood-vessels, supported by a web of areolo-fibrous tissue formed by the interlacement of fine homogeneous filaments, among which nucleated cells are not unfrequently observed."—p. 107.

Saccular Stages.—When the sac closes—

"The space between the pulp and the sac becomes filled with a fluid secretion which distends its cavity, and often produces a conspicuous enlargement in the situation of the tooth."—p. 108.

"On the part of the capsule corresponding with the sides and neck of the crown is a flat portion of the enamel organ, which is destined to the formation of the enamel in that situation. This lamina has a well defined inferior border at a later period in the growth of the enamel organ; the appearance which it presented of a gelatinous mass is lost, and the substance contracts into a membranous layer. At this time also the prominences from the internal surface of the capsule have enlarged, and have become vascular and more closely adherent to the enamel organ. Some writers have inferred from this appearance that the enamel organ itself becomes vascular,* but this is not the fact; it is simply that portion of the capsule which lies in contact with the enamel organ that presents the vascularity referred to.

"The dental capsule being originally, as we have seen, a production of the mucous membrane of the alveolar groove, is attached by its external surface to the neighbouring soft parts by means of loose areolo-fibrous tissue. Blood-vessels ramify very freely in this tunic, and from the interlacement which they then form, numerous capillary loops are given off, which extend into the superficial portion of the membrane. These vascular loops are separated from the enamel organ by a delicate layer of cells, the characters of which have been already explained.

"Not the least interesting of the features attendant upon the development of the teeth is the relation which the capsule bears to the pulp and to the tooth at various periods of its growth. In the follicular and early periods of the saccular stage, previously to the commencement of the formation of the ivory, the capsule is continuous with the base of the dental papilla;† and at a subsequent period, when the ivory of the crown

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* Raschkow, in a note appended to his Researches, remarks that he has observed the enamel organ to receive blood-vessels in certain parts, and believes the parenchyma of the organ to be pervaded by capillary vessels. The conclusion which he deduces from this observation is, that the enamel organ was from the beginning joined to the capsule.

† It passes upwards over it, forming a distinct envelope, separated from the layer of mucous membrane externally.

forms a complete covering to the pulp, the same arrangement takes place. But at a more advanced stage in the growth of the tooth, when its formation has proceeded beyond the limit of the crown, the capsule attaches itself closely around the neck, and the connexion of the two structures is so firm, that every attempt to effect their separation generally results in the laceration of the membrane. The continued growth of the tooth carries the capsule upwards with the rising alveolus to the under part of the gum, which now stretches over it; when pressed upon by the surface of the crown, it becomes atrophied and absorbed. No portion of the capsule seems to pass down into the alveolus."—p. 110.

Everything that I have seen confirms this admirable description as to matters of fact, and the only objections I shall have to offer are to certain of Mr. Nasmyth's conclusions.

In Man, then, as in the Skate, the Mackerel, and the Frog, the tooth-pulp is a dermic process bounded by its basement membrane; the capsule is an involution of the derm, bounded by its basement membrane; and the epithelium of these organs lies between them, having in this case received the name of "*Enamel-organ*," from the supposition that the enamel was developed by the calcification of its elements. Of this, however, I shall speak below.

There is an important difference between the dental sac of the Calf and that of Man, which has given rise to much confusion.

The "actinenchymatous" tissue (Raschkow) of the former does not at all correspond with the stellate tissue of the latter, as has been assumed by all writers. In fact, in the Calf the wall of the capsule is separated by only a very narrow space from the surface of the pulp, and this space is completely filled up by elongated cylindrical epithelium cells, which glue the capsule to the pulp. Between the basement membrane of the capsule and the alveolar wall, indeed, there is a very wide interval (see Owen, *l. c.*, pl. CXXII. *a*, fig. 9 *e*) occupied by Raschkow's actinenchyma. This, however, is nothing more than the loose submucous cellular tissue of the gum, similar to that so well described by Mr. Nasmyth in the wall of the capsule of man. Professor Owen says (*l. c.*, Introduction, p. lix.) that "no capillaries pass from the capsule into the actinenchymatous pulp of the enamel." But those which I have examined do not bear out this statement; in fact, this tissue presents one of the most beautiful and obvious vascular networks with which I am acquainted.*

The true homologue of the "enamel organ" in Man therefore, in the Calf, is not the actinenchymatous tissue, but the thin

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* Blake, who wrote in 1801, mentions the vascularity of the "spongy" outer membrane of the tooth sac in the calf; he says it is "very vascular."—p. 81.

layer of epithelium between this and the pulp. The general relations of the different dental organs are, in other respects, the same in the Calf as in Man.

I may now proceed to the second question. *What is the relation of the proper dental tissues to the three organs of the tooth capsule?*

The answer is shortly this. Neither the capsule nor the "Enamel-organ" take any direct share in the development of the dental tissues, all three of which—viz. enamel, dentine, and cement—are formed beneath the membrana preformativa, or basement membrane of the pulp. In proof of this assertion, I have to offer the following facts:—If, in a human fœtus of the seventh month, a dental capsule (say of an incisor) be treated as I have above described, it will generally happen that the surface of the young tooth-cap appears quite smooth under a low power; or it may be that a few of the elongated cells of the "*organon adamantinæ*" adheres to it. In any case the adhesion is loose, and these cells may be readily detached. Under a higher power the surface of the upper part of the ossified cap appears reticulated, the meshes being about 1-5000th of an inch in diameter. At the lower part, where only a thin layer of dentine is formed, this appearance is less distinct, but the surface is somewhat wrinkled, the wrinkles sometimes forming large and pretty regular meshes. Viewed in profile, these wrinkles are seen to be produced by the folding of a delicate structureless membrane, which is continuous below with the *membrana preformativa*. Towards the apex the tooth substance is almost too opaque to make much out of it; the yellowish enamel, however, can generally be distinguished from the dentine.

Now, while the object is under a low power of the microscope, add some strong acetic acid; a voluminous transparent membrane will immediately be raised up in large folds from the whole surface of the tooth. If the acetic acid be pretty strong, it soon softens the substance of the tooth a little, and then a slight pressure exhibits very distinctly the *ends of the enamel fibres under this membrane.* There can be no question about this fact, as I have been able to demonstrate it to the satisfaction of my friends, Mr. Busk and Professor Quekett. The membrane is about 1-2500th to 1-1600th of an inch thick, perfectly clear and transparent, and under a high power exhibits innumerable little ridges upon its outer surface, which bound spaces sometimes oval and sometimes quadrangular, and about 1-5000th of an inch in diameter. Furthermore, at its lower edge this membrane gradually loses all structure, and passes into the *membrana preformativa*.* *In fact, it is the altered membrana preformativa itself*, no trace of which has ever yet been found in the locality in which, according to the prevalent hypotheses upon the development of the teeth, it should exist—viz., between the enamel and the dentine.

In the Calf † a similar membrane may be demonstrated, but it is much more delicate, and I have not seen the peculiar areolæ upon its surface.

In the Frog, in which the layer of enamel is very thin and structureless, the membrane (*fig.* 8) may be very readily demonstrated by the action of dilute hydrochloric acid, which in this animal, as in the Mackerel and Skate, dissolves out the enamel layer at once, while it only acts gradually upon the dentine.

In all these animals I have examined the smallest teeth I could find perfectly entire, without any rough mechanical treatment, which I should think would destroy the delicate membrane.

In the Frog, its surface is in parts *reticulated, as in Man;* in the Mackerel and Skate (*figs.* 9, 12) I have been unable to find any such reticulation. In both these the enamel forms a conical cap of almost structureless or obscurely fibrous substance at the extremity of the tooth, while the layer upon the body of the tooth is very thin.‡ In the Skate it is thick, dense, yellowish, structureless, and perfectly smooth; but in the Mackerel it is developed upon the lateral edges of the young tooth into sharp notched processes; lines stretch across the body of the tooth from these, not unlike the contour lines one sees on the enamel of a young human tooth.

A membrane, corresponding with that which has been described in the human subject then, is also found in members of each of the other groups of Vertebrata which possess teeth. In the human subject, and in Mammals, this membrane was

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* It is stated, by all the writers on the subject whom I have consulted, that the membrana preformativa is the first portion of the tooth which ossifies. This statement, however, is never supported by evidence; and my own observations lead to precisely the reverse conclusions.

† *See* Hassall, Micr. Anatomy, p. 318.

‡ As this "dense exterior layer" may be dissolved out by dilute acid, leaving the "membrana propria of the pulp," which is very much thinner, standing, it is quite clear that it is not "formed by the calcification of the membrana propria of the pulp, which therefore precedes the formation of ordinary dentine."—(*Odontography*, p. 17). Why should it not be called enamel? It has at least as much claim to this title as that of the Frog.

discovered, and very accurately figured and described, fourteen years ago (that is, in January, 1839, in the 'Medico-Chirurgical Transactions), by Mr. Nasmyth, under the name of the "persistent capsular investment." No question has ever been raised as to the right of Mr. Nasmyth to this discovery; but it is remarkable, that neither in Professor Owen's 'Odontography,' which is the first subsequent work upon the teeth, nor in Professor Kölliker's 'Mikroskopische Anatomie,' which is the last, is there any notice of Mr. Nasmyth's discovery. Kölliker, indeed (*l. c.*, pp. 76, 77), describes the structure as "schmelz-oberhäutchen," but his description is not so good as that of Nasmyth, and he states that it does not extend over the cement—Nasmyth having shown that it does. Unfortunately, however, the latter, like all who have succeeded him, misled by the supposed mode of development of the enamel from the enamel-organ, imagined that, as the "persistent capsule" was outside the enamel it could be nothing else than the membrane of the dental capsule; and hence the erroneous description of the adherence of the latter to the crown of the tooth, which I have already quoted. Had he chanced to examine a tooth before its eruption, he would at once have seen the incorrectness of his hypothesis.

Since then this "Nasmyth's membrane" is identical, on the one hand, with the persistent capsule which lies external to both enamel and cement, and, upon the other hand, with the preformative membrane of Raschkow, or otherwise with the basement membrane of the pulp; it is clear that all the tissues of the tooth are formed *beneath the basement membrane of the pulp;* in other words, they are all true dermic structures—none epidermic.*

The third problem was, the relation of the histological elements of the soft parts (that is, as we now see, of the pulp) to the Dentine, Enamel, and Cement.

Three theories have been prevalent as to the mode of development of the dentine. The first, the old *excretion theory*, need not be considered here, as it has been given up on all sides. The second, the Conversion theory, consists essentially

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* That the enamel is not formed directly from the enamel pulp might have been concluded from Professor Goodsir's observations (*l. c.*, p. 25). He says, "The *absorption* (in the granular matter) goes on increasing as the tooth substance is deposited, and when the latter reaches the base of the pulp, the former disappears, and the interior of the dental sac assumes the villous vascular appearance of a mucous membrane. This change is nearly completed about the seventh or eighth month." It will not be said, however, that the growth of the enamel ceases at the seventh or eighth month.

in the supposition that the dentine is the "ossified pulp;" that the histological elements of the pulp become calcified and converted directly into the dentine—the arrangement of the elements of the dentine depending upon that of the elements of the pulp. This is the doctrine maintained by Blake, Schwann, Nasmyth, Owen, Tomes, Henle, Todd and Bowman, and, more or less doubtfully, by Kölliker and Hildebrandt.* The third theory is that contained in the remarkable phrase of Raschkow.

> "Postquam . . . fibrarum dentalium stratum depositum est (quoted by Schwann) idem processus continuo ab externa regione internam versus progreditur *germinis dentalis parenchymate materiam suppeditante* . . . . Conversæ fibrarum dentalium flexuræ quæ juxta latitudinis dimensionem crescunt, dum ab externa regione internam versus procedunt sibi invicem appositæ continuos canaliculos effingunt, qui ad substantiæ dentalis peripheriam exorsi multis parvis anfractibus ad pulpam dentalem cavumque ipsius tenduut, ibique aperti finiuntur novis ibi quamdiu substantiæ dentalis formatio durat fibris dentalibus aggregandis inservientes."

The dentinal substance, that is, is deposited within the pulp beneath the membrana preformativa in definite masses (Raschkow calls them fibres, to which, indeed, under a low power they have a remarkable resemblance), the gaps between which eventually constitute the dentinal tubules. This, if a name be wanted, might be called the Deposition Theory, and is especially characterized by its asserting that the histological elements of the pulp do not enter *as such* into the dentine. The following description of the young dentine in the human subject holds good for all the animals which I have examined; and if it be true, I think the incorrectness of the Conversion Theory necessarily follows.

To justify my own method of procedure, however, I am necessitated to remark that I have been unable to verify the statement of Professor Owen (*l. c.*, Introduction, p. xxxix.), that the teeth of Man "will not yield a view of the cap of new-formed ivory and the subjacent pulp in undisturbed connexion by transmitted light with the requisite magnifying power." On the contrary, I have found it sufficiently easy, by cutting off the half-ossified cusp of a young molar, or even by submitting an entire canine or incisor to slight pressure, to obtain a most distinct view of the pulp in undisturbed connexion with the dentine, and in a profile view. Indeed,

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* Dr. Sharpey, on the other hand, with characteristic caution, after citing the statements of some of the advocates of the Conversion Theory, adds, "We must confess that, after a careful examination of the human teeth, we have been unable to discover any of the above-mentioned changes, except the enlargement of the more superficial cells of the pulp, and their elongations in the immediate vicinity of the dentine."—Quain and Sharpey, p. 988.

had other observers adopted this method, I do not think they would have been led to consider the lacunæ in young dentine, whose true nature was demonstrated by Raschkow, as metamorphosed nuclei of the pulp.

When the ossifying boundary of a tooth-pulp is examined in the way which I have here pointed out, it is seen that where dentification has not begun, the membrana preformativa is in immediate contact with the substance of the pulp, composed of a homogeneous transparent base, in which closely-arranged "nuclei" are embedded. These are rounded or polygonal, apparently vascular; contain one or more granules, and are about 1-2500th—1-3500th of an inch in diameter. Passing towards the ossifying edge, we see in the profile view a clear, more strongly refracting layer, gradually increasing in thickness, which begins to separate the proper substance of the pulp from the membrana preformativa. This is at first quite structureless to all appearance, both in this view and in one perpendicular to its surface. When it has attained a thickness of 1-2500th of an inch, however, it acquires a sort of mottled appearance in the profile view, while superficially numerous very minute irregular cavities, about 1-5000th of an inch apart, present themselves (fig. 5). In a thick portion of the dentine (3-5000ths) these cavities are very readily seen in the profile view to be elongated into canals; superficially they are rather larger; and as they run somewhat obliquely, it may very readily happen that, unless the focusing of the microscope be very careful, one will run into the other, and so produce the appearance of fibres described by Raschkow.

This young dentine is as transparent as glass. No trace of "nuclei" can at any time be discovered in it; the bodies which have been described as such being, as I have said, simply lacunæ; nor, if strong acids be used so as to dissolve out the calcareous matter, are any nuclei brought to light, though those which exist in the pulp became much more distinct, and even coarse, in their outlines. Again, if to a pulp thus treated, a weak solution of iodine be added, the nitrogenous substance of the pulp is immediately coloured deep yellow, the nuclei themselves becoming brown; but the dentine remains pale, except that here and there a yellow process of the matrix of the pulp may be seen stretching a little way into one of the canals of the dentine. I have only observed this, however, once. I believe that these facts afford sufficient demonstration that the pulp is *not* converted directly into the dentine, and that, the structure of the latter does not depend upon the calcification of pre-existing elements.

I am the more satisfied with this negative evidence, as in young bone it is easy to demonstrate the "nuclei" in the lacunæ by the aid of acids, &c.

As to whether the perpendicularly crowded "nuclei" of the pulp under the dentine disappear, or whether they are merely pressed inwards, I cannot pretend to offer a decisive opinion. The former supposition, however, if we may judge by the analogy of bone, appears more probable. Dentine, in fact, might be considered as a kind of bone, in which the lacunæ are not formed in consequence of the early disappearance of the nuclei, whose persistence for a longer or shorter period appears to be the sole cause of their existence in bone.*

Still less can the enamel be produced by any *conversion* of a cellular structure. Between it and anything which can be called a nucleated cell it has on the outer side Nasmyth's membrane; on the inner, the layer of dentine, which in Man is formed before it. The fibres of which it is composed are structureless, and almost horny; and I think we must be content for the present to consider its existence and its structure as ultimate facts, not explicable by the Cell Theory. It is particularly worthy of notice that in the Skate the dermal teeth or plates on the upper surface of the head have as distinct a layer of enamel as those of the mouth, though in this case there is most assuredly neither rudimentary capsule nor "enamel organ."

In a morphological point of view, the relations of the cement show it to be homologous with the enamel. In a very beautiful section of a human tooth from Mr. Busk's cabinet, the upper portion of the cement exhibits in places a very distinct transverse striation, resembling its perfect enamel. But the transition of the one structure into the other is best exhibited in the young Calf by the cement of the fang of a molar which had not cut the gum. Here it is a white substance, from which generally a fitting section can be cut only with some difficulty, in consequence of its friability. The layer is about 1-40th of an inch thick, and consists of an external delicate structureless Nasmyth's membrane; internal to which three-

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* I have here no space to enter into the discussion of the various hypotheses and assertions, respecting the development of the dentine, made by the various authors whose names I have cited. I trust it will not on that account be supposed that I have neglected to make myself acquainted with them. But there are two statements to which I must refer in confirmation of my own view. The one is that by Dr. Sharpey already quoted: the other is the very just declaration (in italics) by Professor Kölliker (Handbuch, p. 386), that "*the most careful investigation exhibits no trace of any elongation of nuclei*" in the peripheral cells of the pulp.

fourths of the thickness of the layer are formed by parallel fibres 1-5000th of an inch in diameter, quite structureless, and completely resembling enamel fibres, but absolutely enormous (as much as 1-60th of an inch) in length. These fibres were softened and rendered pale by the action of caustic ammonia. The inner fourth of the layer of cement was composed of an inextricably interlaced body of such fibres, united into a mass, which in some places was almost homogeneous, by calcareous salts, and containing here and there lacunæ 1-1600th of an inch in length, similar to those of bone. That this structure was the young cement is certain, inasmuch as no enamel is formed on the fang of the tooth, to say nothing of the presence of the lacunæ. On the root of the fang of the molar in front of this, which had cut the gum some time, and had come into use, the cement had the ordinary structure. It may be worth while to add that in these teeth the capsule, though closely connected with the outer surface of the fang, could be readily stripped from it, and then exhibited a layer of epithelium upon its inner surface, showing clearly that the cement was not derived from its ossification.

It may be concluded, then,—

1. The teeth are true dermic structures, formed by the deposit of calcareous matter beneath the basement membrane of a dermic papilla, or that which corresponds with one.

2. Neither the capsule nor the "enamel-organ," which consists of the epithelium of both the papilla and the capsule, contribute *directly* in any way to the development of the dental tissues, though they may *indirectly*.

3. The histological elements of the pulp take no direct part (except, perhaps, eventually in the cement) in the development of the dental tissues, becoming either absorbed or being pressed in by the gradual increase of the latter. The Conversion Theory is, therefore, as incorrect as the Excretion Theory, and the dentine is formed, not by ossification of the histological elements of the pulp, but by deposition in it, "parenchymate materiam suppeditante."

I have already exceeded my limits, and I must, therefore, dismiss my last point very concisely. The true homologues of the teeth in Man are, I think, the Hairs. As Hildebrandt says, "As the Hairs in their bulb (sac), so the Teeth are developed in their capsules." The stage of the free papilla, which does not occur in the hairs of man, is absent in the teeth of the Mackarel and Frog, and, indeed, it would seem in the permanent dental capsules of man also.

Substitute corneous matter for calcareous, and the Tooth would be a Hair. The cortical substance of the hair contains canals not unlike those of the dentine; its relation to a dermal papilla is the same as that of the dentine:* for although it is universally stated to be such, I think it can be shown that the hair shaft is *not* an epidermic structure, but a dermic one.

Again, the so-called cuticle of the hair corresponds in all respects, except absolute and relative size, with the enamel—its inner layer with the enamel proper—its outer with Nasmyth's membrane. On the root of the hair the cuticle is not continuous with the proper epidermic cells, but with a structureless membrane, which occupies more or less distinctly the place of a *membrana preformativa*. The two root-sheaths, again—true epidermic structures, but which do not enter all into the construction of the hair proper—represent the altered and unaltered portions of the "*enamel-organ*."

Hairs and *Teeth*, then, are organs in all respects homologous, and true dermal organs. Under the same category, probably, will come Feathers and the Scales of fishes.

The Nails, on the other hand, seem to be purely epidermic, at least according to Kölliker's account of their development (*l. c.*, p. 119); and in that case they are the homologues of the root-sheaths and enamel-organs of Hairs and Teeth.

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* *See* Todd and Bowman, p. 175.

On the Photographic Delineation of Microscopic Objects by Artificial Illumination. By GEORGE SHADBOLT, Esq.

THE application of Photography to the purpose of delineating microscopic forms I have for some years entertained as a favourite project; but some practical difficulties of manilation deterred me from putting it to the test until quite recently, when a sufficient stimulus was applied in the beautiful specimens both on paper and glass exhibited in the month of October last, at the Microscopical Society of London, by Mr. Joseph Delves, of Tonbridge Wells. Of the excellent promise for a highly valuable adjunct to microscopic science, the proofs in the present Number of the Journal will afford your readers an opportunity of judging.

As it is not my intention to enter into particulars of the rise and progress of this art as connected with the microscope, I will only observe that the earliest microscopic photographs which I had the pleasure of seeing were some Daguerreotypes executed by Mr. Richard Hodgson by the aid of the *direct rays of the sun;* and for these I believe he is entitled to claim the honour of having been the first to produce a picture of this kind.

But however beautiful the sharpness and detail of pictures upon metallic plates, there are many causes to confine the practice of the Daguerreotypic art within such very contracted limits as to render it of but little use to the microscopist; whereas the increasing beauty and sensibility of the Collodion process renders it a much more encouraging medium for further experiment in this direction, besides offering the additional inducement of enabling one to transmit duplicates upon paper to others engaged upon similar observations at a distant part, by which comparisons of much value can be made, and without the expense and inconvenience of having to execute duplicates from the objects themselves.

As it happens that the great majority of the followers of microscopic science are mostly engaged in professional or other business pursuits during the day-time, and in most instances at a distance from home, it occurred to me that if *artificial light* could be made to act sufficiently energetically to produce microscopic pictures, it would be a very considerable advantage to a large number of persons who would otherwise not be able to avail themselves of so excellent an assistant as the photographic art; and further, that to render it practically useful, it must be done by an illumination *readily accessible* and *inexpensive;* I therefore determined to institute a series of experiments with this end in view, and having availed myself of all the hints thrown out by Mr. Delves, Mr. Hogg, and others, at the Microscopical meeting in October, after very many failures and no small amount of trouble, I at length was fortunate enough to meet with such success as, in my opinion, to offer very considerable encouragement for further operations with a reasonable hope of a really useful result; and at the meeting of the Microscopical Society in November last I had the pleasure of exhibiting a picture of a Fly's Proboscis, produced by the aid of a very small camphine lamp. In the hope of enlisting more labourers in this field of research, I purpose detailing the "modus operandi" which I have found most successful; trusting that, in a short time, the little seed thus sown may bring forth an abundant harvest.

I would premise that I do not advocate photography in microscopic science as a rival that will *supersede* the draughtsman, except in certain cases; and although it may in very many instances do so, it will most assuredly *make* much more work than it takes away from those who follow the occupation of a microscopic artist.

When the object to be delineated is flat and moderately thin, as compared with the necessary power in use, a very excellent picture may be produced without any aid from the limner; but where the object is not so formed—although when under microscopic examination the mind can readily acquire a correct knowledge of the form by focussing up and down—it is evident that from the very construction of a good objective a *picture* can only be obtained in *one plane at a time*, and it will then be necessary to take several pictures in different planes, and call in the artist's aid to unite the productions. The immense amount of time and labour that can be thus saved in delineating subjects of an elaborate character can only be appreciated by those who have attempted the production of objects of this class.

It is scarcely necessary to enter into a preliminary explanation of the photographic phenomena, as it is of very little use for an entire novice in the practice of this art to commence upon microscopic subjects; I shall, therefore, presume that I am addressing those who understand the general principles of photography, and shall therefore commence with

The Arrangement of the Apparatus.—Place the microscope with the body in a horizontal position, and screw on the objective to be used, and fix the object in its proper position on the object-plate of the stage by pressing down the sliding spring-piece. Turn the mirror aside or remove it altogether, and having taken out the eyepiece, insert into the body a tube of brown paper *lined with black velvet*, in order to prevent the slightest reflection from the sides, which would infallibly spoil every picture if allowed to operate. The lens should then be removed from an ordinary photographic camera, and the latter elevated so as to bring its centre in an exact line with the axis of the microscope body, which must have its eyepiece-end inserted in the place left vacant by the removal of the camera lens, and that portion of the opening not filled up by the body may be rendered impervious to light by a piece of black cloth, velvet, or other similar material.

The lighted lamp must next be brought, so that the centre of the flame is in the axis of the instrument, and its distance must depend upon the focus of the lens used to concentrate the light, for which purpose an ordinary convex lens of 2½ to 3 inches diameter, with its flat side towards the lamp, is perhaps as useful as any, provided a second plano-convex lens of that focus is interposed near the object to concentrate the light still more strongly. It is not necessary, or even desirable, that an *image* should be formed of the source of light, and consequently the spherical aberration in such an arrangement as recommended is *not* detrimental, and *may be* advantageous.

The ground glass screen to receive the image being in its proper place in the camera, the object may be brought to a correct focus in the usual way with the coarse and fine adjustment, and this cannot be done too accurately; in fact, for delicate objects, a means of magnifying the image is absolutely requisite, and for this purpose a positive eyepiece, placed in contact with the ground glass, is perhaps best.

Most achromatic objectives of the best construction are slightly over-corrected (as it is termed) for colour, in order to compensate for a small amount of under-correction in the eyepiece, that is to say the violet and blue rays of the spectrum are therefore projected beyond the red ones.

As it is ascertained that most of the photogenic or actinic rays are located in the violet end of the spectrum, it follows that with such a lens as is used for the microscope, the *chemical focus* will be somewhat more distant from the object than the visual focus, and it therefore becomes necessary to make some allowance for this difference.

This may be done in two ways, either by placing the sensitive plate somewhat farther off than the ground glass on which the image is received, or by altering the focus by the fine adjustment; the latter being the plan I prefer, as I find it much more accurate.

The *amount* of difference between the foci probably varies in every objective, even apparently of the same make, and can only be ascertained by direct experiment, but the following may be some guide to those who wish to experiment upon the subject.

An *inch-and-a-half* objective of Smith and Beck's make required to be *withdrawn from* the object after the correct visual focus is ascertained 1-50th of an inch, or *two turns* of *their* fine adjustment.

A *two-thirds of an inch* object glass of same make wants a withdrawal of 1-200th of an inch, or ½ a turn of the fine adjustment, and

A 4-10ths of an inch, about 2 divisions, or 1-1000th of an inch farther off. With the 1-4th, and higher powers, the difference between the foci is so minute that it is *practically* unimportant. The above differences are those actually existing in my own objectives, but, as before intimated, it does not follow that they will be correct for others even of the same makers.

Having arranged the apparatus, focussed, and made the requisite adjustment for chemical focus, the ground glass may be removed, and the sensitive plate placed in its stead.

As in all other photographic processes, the time of exposure must be varied according to the power in use, the nature of the object to be taken, and the amount of illumination, to which must be added in the present instance the *medium in which* the object is mounted, but from 1 *to* 10 *minutes'* exposure is generally requisite. An explanation of the last named disturbing cause may probably be found in the beautiful discovery of Professor Stokes of the property possessed by certain transparent media of arresting the chemical rays.

Any account of the preparation of the collodion, &c. &c. would be more fitted for a work on photography, and would render the present paper much too lengthy: moreover there is an abundance of information on photographic manipulatory details readily accessible in numerous publications, such as Mr. Robert Hunt's Manual, Mr. Bingham's, Mr. Archer's, Mr. Horne's, Mr. Hennah's, &c. &c. There are, however, one or two points which it is as well to allude to. If the film of a collodion picture be examined by the microscope, some specimens will present an appearance very much resembling condensed cellular tissue, such as that seen in the cuticle of leaves, being apparently made up of flattened irregular hexagonal cells; while others seem to consist of an entirely structureless amorphous mass; the latter sort of collodion is most suitable for microscopic purposes.

The final fixation of the picture by removal of the iodide of silver has a singular influence upon the result according to the method employed, and advantage may be taken of this in order to improve the effect according as it is desired to produce glass positives or negatives; for though all collodion pictures partake of *both* characters, one of the two *should* always be predominant.

Of course a negative is most useful, because the drawings can be multiplied upon paper almost ad infinitum, but for certain objects the amount of detail when *very delicate* is inconceivably better shown upon glass than upon paper. If then a negative picture be desired, it is best to develope with the pyrogallic acid solution, and *fix* with a solution of hyposulphite of soda; but if, on the contrary, a positive picture is the desideratum, the effect will be infinitely better by fixing with a bath of the following, viz.:—

Cyanide of Potassium	1½ drams.
Water	1 pint.
Nitrate of Silver	15 grains.

The cyanide to be dissolved in the water, and the crystals of nitrate of silver added, which immediately cause a curdy precipitate, but this is quickly redissolved, and the whole becomes quite translucent.

By this method of fixing, the *whites* are very much purer and brighter than when the hyposulphite is used, but the pictures do not answer so well for printing from. A still further intensity of the whites may be produced by *developing* the picture with a solution of the *proto-sulphate of iron*, instead of the pyrogallic acid, and afterwards fixing with the cyanide solution; there are, however, certain difficulties of manipulation to overcome. The solution is made as follows:—

Proto-sulphate of Iron in Crystals		1 oz.
Water	by measure	10 oz.
Sulphuric Acid	„	1 cz.

This is best used by placing in a *glass* bath and *totally immersing* the plate, which should be withdrawn *the moment* the picture is perfectly developed, which will be in from 15 to 60 seconds, and it ought to be instantly plunged into a bath of plain water sufficiently copious to dilute the adherent moisture very considerably. The object of the bath being of glass, is in order to see the development of the picture, as every *second* it remains after it is fully produced, is to the detriment thereof, by causing a sort of fogginess to appear all over it.

When developed with the protosulphate of iron, the pictures may be exposed to direct day-light before the final fixing, without injury, in fact with positive benefit according to Mr. Martin.

The causes most frequently operating to prevent the success of the process are, *first*, want of attention to the proper illumination; it is to this point more than any other that the utmost attention should be paid, and I feel confident that by well concerted measures to attain this requisite, we shall eventually be able to obtain pictures in a tithe of the time now necessary; in the second place failures more often occur from *over exposure* than from being too short a time; thirdly, want of allowance for difference of visual and chemical foci.

In conclusion, I would observe that some experiments upon the different *light-producing* substances would in all probability well repay the trouble of testing their capabilities, as from certain hints thrown out by Professor Stokes, there appears to be a very considerable difference in the amount of actinic rays emitted by differing combustibles, and it seems not improbable that a well contrived *spirit lamp* may be found highly advantageous to use while taking the impression, although its light-giving properties are so defective. I hope shortly to be able to resume this subject.

On the Teeth on the Tongues of MOLLUSCA. By J. E. GRAY, Ph.D., F.R.S., V.P.Z.S., P.B.S., &c.

LISTER, Leeuwenhoeck, Swammerdam, Poli, Cuvier, Fleming, Delle Chiaje, Verany, Eydoux, Souleyet, Van Beneden, Oersted, and some other naturalists, have, at various and distant periods, described and figured the teeth on the tongues of isolated species of Mollusca.

Dr. Troschel, in Wiegmann's 'Archiv,' 1836, 257, t. 9 and 10, and 1839, 177, t. 5, f. 8, describes and figures the teeth of some German terrestrial and aquatic Mollusca. In the same Journal, 1845, 197, t. 8, f. 6, the teeth of *Ampullaria*, and in 1849, 225, t. 4, he has described and figured the teeth of some exotic *Bulimi* and *Naninæ*.

The Rev. Mr. Berkeley, in the Zoological Journal (iv. 278), describes the teeth of *Cyclostoma elegans*.

Dr. Wyman, in the Boston Journal of Nat. Hist., has described and figured those of *Tebenophorus* and *Glandina;* and Mr. Thomson, in the Annals and Magazine of Natural History (1851, vii. 86, t. 3), has published a very interesting essay on the dentition of British *Pulmonifera*.

MM. Quoy and Gaimard, in their large government work, figured the teeth of several marine genera of exotic Mollusca; but, unfortunately, on verification, the figures of some of the genera are so incorrect as to throw doubt on the others.

Dr. Lovén, in his very excellent paper on the Mollusca of Scandinavia, made some important observations on the teeth of some marine Mollusca; and in a special paper on the subject (Oversigt. af Kongl. Vetensk. Akad. Förhandl., 1847, 175) he describes and figures the teeth of the several orders, families, and genera of Scandinavian Mollusca. He divides the tongues he has seen into fourteen groups, and separates the genera into families and sections, characterized by the number, position, and forms of the teeth, which opened a new series of characters for the systematic descriptions of the Mollusca.

Messrs. Alder and Hancock, in their beautiful work on British Nudibranchia, and Messrs. Hancock and Embleton, in the Philosophical Transactions for 1852, have figured the teeth of several British Nudibranchiate gasteropods; and Dr. Troschel, in Wiegmann's 'Archiv' (1852, 152 t.), MM. Eydoux and Souleyet, Voy. de Bonite, M. Oersted, and myself in a paper in the Annals of Natural History for 1853, have described and figured the teeth of some genera of marine Mollusca which had not been before described.

Mr. Hancock and Dr. Embleton (Phil. Trans., 1852, 211) have described the development, wearing, and succession of the teeth of the *Dorides;* they observe, " the mode of growth of the spiny tongues of *Doris* is evidently quite analogous to the growth and advance of the teeth of the rays and sharks, &c., or of the hoof and nails of Mammalia."

Dr. Troschel, in the third edition of Wiegmann and Ruthe's 'Handbuch der Zoologie,' Berlin, 1848, proposed to divide the Gasteropods into four orders, according to the number of the teeth on the lingual band, giving them the names of—1. *Tænioglossa;* 2. *Toxoglossa;* 3. *Proboscidea;* 4. *Rhipidoglossa.*

In some observations on this paper (Annal. and Mag. N.H., 1852, x. 411) I proposed to use the names of these orders as technical terms in the description of the families, and proposed a new one, *Ctenoglossa,* for the numerous uniform teeth of the *Pulmonata* and other genera; and in a paper on the families of *Ctenobranchiate* Mollusca (Annal. and Mag. N. H., 1853, xi. 124), where I have described some new forms of teeth, I have extended the number of terms so proposed.

Believing that it will be useful to science to have a series of terms to indicate the chief modifications of these teeth which have been observed, I have sent you the following table of them, illustrated with a figure of each form, and with a list of the families of Mollusca which they characterize:—

I. *Rhachiglossa.* The lingual membrane has a single central series of teeth, as in the family *Glaucidæ*, Lovén, t. 3, figs. 15, 16; *Dotonidæ*, *Phyllirrhoidæ*, *Limapontiadæ* of Nudibranchiata; and *Volutidæ* (figs. 1, 2), of Ctenobranchiata.

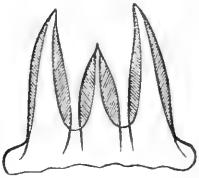
Fig. 1.—Yetus olla.

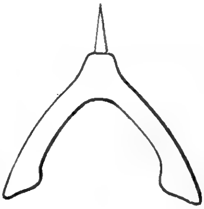
Fig. 2.—Cymbiola Turneri.

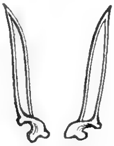
Fig. 4.—Mangelia costata.

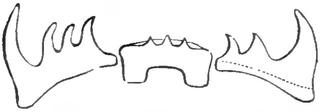
Fig. 5.—Chrysodomus antiquus.

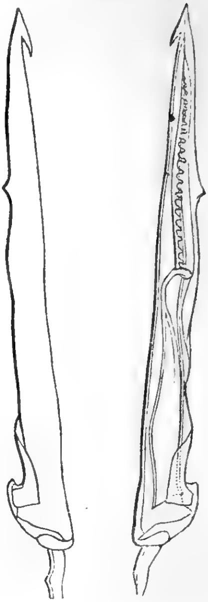
Fig. 3.—Conus, sp.

II. The lingual membrane, with *two* series of elongated subulate teeth, one on each side of the central line.

a. *Toxoglossa;* the teeth elongate, straight, or spiral.
  1. *Conidæ;* teeth with a channel on the side and barbed. (Fig. 3.)
  2. *Pleurotomidæ;* teeth subulate, straight, simple. (Fig. 4.)

b. *Drepanoglossa;* the teeth curved, elongate, slender, compressed, short, conical, strong. *Philinidæ*, *Onchidoridæ*.

III. The lingual membrane, with *three* series of teeth; central teeth simple.

A. *Hamiglossa;* the lateral teeth versatile, attached by the inner end, and capable of being bent over on each side (Fig. 5); as

Muricidæ, *Buccinidæ*, *Olividæ;* with the lateral teeth flat; and

Lamellariadæ; with the lateral teeth curved

B. The lateral teeth bent towards the central one. *Cavolinidæ*, *Limacinadæ*, Lovén, t. 3, fig. 5, 6. *Amphisphysadæ*, Lovén, t. 3, f. 20.

C. *Odontoglossa;* the lateral teeth fixed on the same plane as the central; immoveable (figs. 6 and 7); as

a. *Fasciolariadæ;* the central teeth small, few-toothed; the lateral very broad, many-toothed. (Fig. 6.)

b. *Turbinellidæ;* the central teeth moderate, largely toothed; the lateral moderate, few toothed. (Fig. 7.)

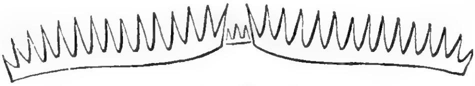

Fig. 6.—Fasciolaria filamentosa.

Fig. 7.—Turbinella cornigera.

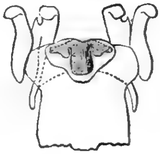

Fig. 8.—Lepeta cœca.

IV. *Oplatoglossa;* the lingual membrane, with *six* series of teeth, the central large, the lateral hooked, similar. (Fig. 8.) *Lepetadæ*.

V. The lingual membrane, with *seven* series of teeth, the central recurved at the top; the inner lateral, broader, recurved at the top.

Fig. 9.—Natica pulchella.

a. *Tænioglossa;* the two other lateral, more or less conical, incurved. (Fig. 9.)

Among Ptenobranchus Gasteropods:—*Pterotrachidæ*, *Atlantidæ*, *Paludinidæ*, *Ampullariadæ*. *Melaniadæ*, *Littorinidæ*, *Valvatidæ*, *Naticidæ* (fig. 9), *Velutinidæ*, *Cypræadæ*, *Trichotropidæ*, *Capulidæ*, *Calyptræadæ*, *Pediculariadæ*, *Cyclostomidæ*, *Helicinidæ*. *Aporrhaidæ*, *Strombidæ*, *Loligidæ*, *Sepiolidæ*, *Octopidæ*.

b. *Dactyloglossa;* the two outer lateral teeth broad, divided into many filiform lobes at the end (fig. 10), as *Amphiperasidæ*.

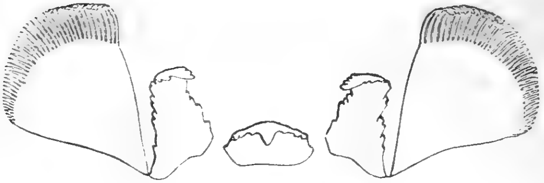

Fig. 10.—Amphiperas Ovum.

VI. The lingual membrane, with *numerous* series of teeth.

A. *Ctenoglossa.* The teeth nearly uniform, similar; the central distinct or wanting.

Among the Pulmobranchiata, as *Veronicellidæ*, *Arionidæ*, *Helicidæ*, *Auriculadæ*, *Lymneadæ*. *Amphibolidæ*, *Siphonariadæ*, *Cyclostomidæ* (?), *Helicinadæ*, *Onchidiadæ* (*Peronia*).

Ptenobranchiata, as *Janthinadæ*, *Scalariadæ* (fig. 11), *Cassididæ*.

Pleurobranchiata, as *Bulladæ*, *Aplysiadæ*, *Amplustridæ*, *Acteonidæ*.

Nudibranchiata, as *Tritoniadæ*, *Doridæ*, *Diphyllidiadæ*.

Pteropoda, as *Clionidæ*.

Fig. 11.—Scalaria Turtoni.

B. *Heteroglossa* central (rarely wanting); and inner lateral teeth larger, often unequal, and variously shaped; the lateral few, uniform. (Fig. 12.)

Amongst the Nudibranchiata, as *Triopidæ* (*Triopa*, and *Idalia*). Lovén, t. 3, figs. 9, 10, 11.

Pleurobranchiata, as *Cylichna* in *Bullidæ*. Lovén, t. 3, fig. 21.

Scutibranchiata, as *Dentaliadæ*, *Chitonidæ* (fig. 12); *Patellidæ* (fig. 13); *Tecturidæ* (fig. 14).

Fig. 12.—Chiton cinereus.

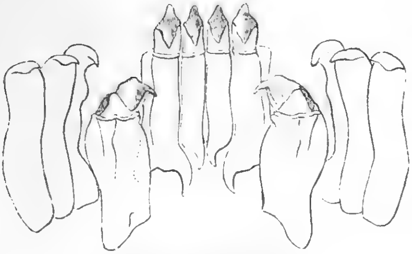

Fig. 13.—Patella vulgata.

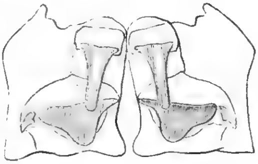

Fig. 14.—Tectura testudinalis.

c. *Rhipidoglossa.* The central and inner lateral teeth larger, often unequal and variously formed; the lateral teeth uniform, very numerous (fig. 15).

Turbinidæ, *Liotiadæ*, *Trochidæ*, *Stomatellidæ*, *Haliotidæ*, *Fissurellidæ*. *Neritidæ*, all belonging to the first division of Scutibranchiata.

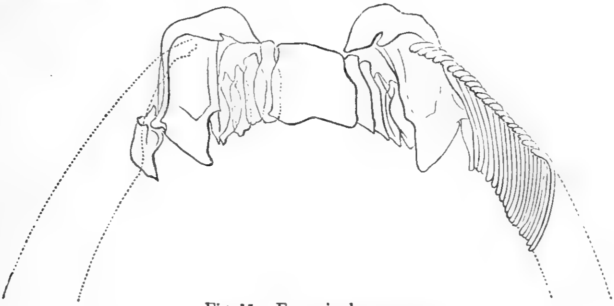

Fig. 15.—Emarginula crassa.

I may observe, that, from the examination I have been able to make of numerous kinds of Molluscs, the teeth offer one of the best characters for their division into natural families. I have such confidence in their permanence and importance in the economy of the animals, that, if I found any very considerable modification in the teeth of two genera which had been referred to the same family, or, much more, of two species, which had been referred to the same genus, I should conclude that they had been erroneously placed in such close proximity—as this modification must indicate an important difference in the habits and manners of the living species under consideration, which had before escaped our observation.

The researches of Dr. Lovén, who has figured and described the teeth of several Scandinavian species of *Nassa*, *Chrysodomus*, *Buccinum*, *&c.*; of Mr. Thomson, who has described the teeth of the various species of British *Helices, Lymnea*, &c. Mr. Alder and Mr. Hancock's researches on the teeth of Nudibranchiata, and my own observation of the teeth of several extra European species of *Tritons, Murices, Fasciolariæ*, &c., show that they offer such modifications in the form, surface, and shape of the edges of the individual teeth as to afford very good characters for the distinction of the species.

They will, therefore, most probably furnish most important characters for the distinction of the species, especially of such genera as *Crepidula, Calyptræa, Patella*, &c., which, from their being long attached to particular places, change the external character of their shells, and thence assume particular forms, which have been regarded as distinct species.

I may add, that the lingual band bearing the teeth, or, as it is termed, the "tongue" of the Mollusca, makes a most interesting object for the microscope; and I hope that persons living in different parts of the globe will make a collection of the tongues of the marine, terrestrial, and fluviatile Mollusca in their neighbourhood, carefully marking the name of the species to which they belong, as by so doing they will afford a most important addition to the knowledge of Malacology.

Excess of the Colourless Corpuscles of the Blood (Leucocythemia) occurring in Cases of Goître. By Thomas S. Holland, M.D., Corresponding Member of the Société Anatomique and of the Parisian Medical Society, Cork.

The impulse which the researches of Professors Bennett and Virchow have given to the study of the histological alterations in the Blood will be, I presume, sufficient excuse for the publication of these observations; and by confining myself to a simple narration of facts I hope to secure the attention of those who live in districts in which Goître is of frequent occurrence, and perhaps induce them to make, in all such cases, a microscopical examination of the blood.

Case 1st.*—Johannah Nissl, aged 70, died in the Allgemeine Krankenhaus of Vienna on the 17th of September, 1851; and dissection made, twenty-eight hours after death, exhibited the following appearances.

Body of the middle height, thin, pale; lower extremities

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* I am indebted to the kindness of Professor Rokitansky for permission to publish these cases, and the preparation, from case No. 1, is in the Pathological Museum.

œdematous, pupils dilated, neck thick, thorax small, sternum prominent, mammæ atrophied.

Head and Neck.—Calvarium porous; a small amount of coagulated blood in the superior longitudinal sinus; pia mater pale, opaque, and œdematous; brain soft, with a half ounce of serum in the ventricles, and small serous cysts on the choroid plexus.

Neck and Thorax.—Thyroid gland so much enlarged that its right half had acquired the size of a man's fist, and the isthmus that of an egg, while a process extending from the latter lay upon the membrana obturatoria. The left half of the gland reached as low as the right ventricle, extending slightly across the chest at the superior opening of the thorax, and measuring three inches in length by one in thickness. The entire mass was made up of small lobules, having the normal structure of the gland, through which passed large and somewhat congested veins containing fluid blood. In each pleural cavity about two pints of brownish serous fluid, which had compressed the inferior lobes of both lungs, and there was much mucus in the bronchi on each side. Two or three ounces of serous fluid in the pericardium; general dilatation of the heart's cavities, more especially the right ventricle, and its base lay a little lower than usual. Pulmonary artery dilated to half again its normal size, while the heart's cavities contained much fluid, or but imperfectly coagulated blood; valves healthy.

Abdomen.—Right lobe of the liver somewhat enlarged, and presenting the so-called nutmeg appearance; in the gall bladder a few drops of yellowish thin gall, its mucous membrane being thickened and œdematous. Spleen normal in size, colour, and consistence. Kidneys rather large, and the cortical substance of a yellowish brown colour. Cavity of the uterus exceedingly small, with the internal orifice of the cervix closed.

Microscopical Examination.—The spleen was most carefully examined, and appeared perfectly free from all trace of diseased action. The fluid and partly coagulated blood taken from the left ventricle exhibited a fine demonstration of that state to which Professor Virchow gives the name of Leukœmie,* and Dr. Bennett† that of Leucocythemia, the colourless corpuscles being about seven or eight times more numerous than they appear ordinarily in healthy blood, and

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* Archiv für pathologische Anatomie und Physiologie. 1852. vol. v. p. 43.

† On Leucocythemia, or White Cell Blood. Edinburgh. 1852.

I had an opportunity of having this observation confirmed by my friend Dr. Robert MacDonnell of Dublin, who was at that time in Vienna.

Case 2nd.—I regret exceedingly having lost the notes of this most interesting case, and in order to avoid mistakes I will only state that, in an autopsy, made in the Allgemeine Krankenhaus, in October, 1852, on the body of a woman, aged about 50, the thyroid gland was found enlarged to four or five times its usual size, while the spleen was in every respect normal. I took blood from the abdominal aorta immediately above its bifurcation, and examined it with Dr. Heschl (first assistant to Professor Rokitansky), expecting to find in it a well marked excess of the colourless corpuscles, *but it presented no such appearance, while blood taken from the pulmonary artery contained so great an excess of these corpuscles that they filled the greatest portion of the field.*

It would be of course quite useless to attempt generalizing from two cases, and I would only suggest that, in all similar researches, the venous and arterial blood of the pulmonic, hepatic, renal, and glandular systems be examined separately, and that the account of the autopsy be as minute as possible, as this state of the blood may be connected with very many diseased conditions.

On the Practical Application of PHOTOGRAPHY *to the Illustration of Works on Microscopy, Natural History, Anatomy, &c.*

By SAMUEL HIGHLEY jun.

MANY scientific phenomena, when first discovered, either from their remarkability or beauty, have excited much interest in the popular mind, but have only been regarded by it as pleasing toys, till in the course of time their practical value has been discovered, and they have been arranged thereafter in the list of applied sciences.

Such was the globe of water, magnifying in distorted form the fly or flower, till in the hands of science it sprung into that exquisite refinement on optical knowledge, "the microscope," that discoverer of hidden worlds and life, and the seat or form of disease within the inmost walls of the human frame. Such the kaleidoscope, the tin case with its bits of coloured glass, regarded long, only as a wonder from the fair, till in practical hands we find ourselves indebted to its aid for many of the beautiful geometric designs which ornament our walls or floors.

So likewise was the camera-obscura, the discovery of Baptista Porta, of Padua, till the progress of chemical knowledge discovered to us the means of fixing its fleeting shadows; and even then its product, together with its adjunct, the stereoscope, was little thought of in its most valuable practical bearings; but of late this has rapidly impressed itself upon us, and we cannot as yet see the limits of its utility.

In Microscopy, Natural History, Physiological and Pathological research, what an invaluable agent will Photographic art prove; for Nature here depicts herself with her own pencil, and, in all probability, ere long from her own palette; and in this resides one of its greatest values, for *truthfulness* is insured, and our studies delineated with a faithful and unbiassed hand; and with what minuteness of detail, the photographs in this Journal bear witness. With regard to good photographs from the microscope, as we have presented to our view what the eye itself would only see if directed to the field of that instrument, we may expect many valuable records of histological research soon to be in circulation, to elicit further investigation.

In delineating the peculiarities of the Geological features of a country, or of its Flora and Fauna especially, where species that could not be acclimatized to other regions are concerned, the naturalist will appreciate its aid.

To the old complaint of the surgical anatomist, that little can be gained from flat plates, a new atlas may be opened by the application of stereoscopic principles to photographs of well-dissected surgical parts.

To the physician it offers a means in many cases of conveying to the student an idea of the "Physiognomy of Disease," as already has been shown by Dr. Diamond's interesting collodion series of 'Types of Insanity;' whilst in the accident ward, or the operating theatre, the exact delineation of many a curious and interesting case might, in a few seconds, be added to the records of its hospital, when time and the restlessness of the sufferer would not permit a draftsman to exercise his art.

Convinced of the value of this beautiful art, the offspring of physical and chemical science, it is with a considerable degree of gratification that, as one of the Publishers of the Microscopic Journal, I am enabled to lay before the world in the plate which accompanies Mr. Delves' paper its first practical application as a printing process to the illustration of scientific literature, a field where it will be mostly appreciated. And it is to the principles involved, and the processes and apparatus employed, that I devote this paper, for the information of those of our readers who may be unacquainted with the details of Photography.

Photographic phenomena are dependent on the power of certain rays, of which white light is composed, to effect the decomposition of certain chemical bodies when presented to their action.

When white light is decomposed by the refracting influence of a glass prism, it is resolved into a spectrum, which appears to be constituted of seven rays, viz., violet, indigo, blue, green, yellow, orange, and red; and the experiments of Sir John Herschel and Professor Stokes prove the further extension of the violet rays into lavender and spectral blue rays, and the red into a crimson ray, though these are not visible to the unassisted eye. Sir David Brewster has, however, proved that this spectrum consists only of three primary rays, blue, yellow, and red, which overlap each other, and thus by their combination produce the other spectra. These primary rays may be recognized in every part of the visible spectrum, and each seems to be possessed of a different physical property: thus *Thermotic*, calorific, or heating effects reside in the red rays, *Light* or luminous effects in the yellow rays, and the *Actinic* or chemical effects in the violet and the rays beyond it.

Photography (light-drawing) and Heliography (sun-drawing) seem therefore to be inappropriate terms, since the *light-giving* rays are by experiment shown not to be the chemical agent in the phenomenon, and artificial light produces actinic effects as well as the sun. But as, whenever photographic effects are produced, actinism is the agent, I would venture to suggest that the term *Actinography* would appear to be most correct.

When surfaces prepared with agents sensitive to the actinic rays are exposed to light, a molecular change sets in, and the surface darkens all over; if, however, we protect any part, as by interposing a piece of black lace or a transparent print, we obtain a faithful outline of the first and an imprint of the second; but in both instances the natural appearance is reversed, for the parts exposed most to the light darken, whilst those parts protected remain white; thus the black lace placed on light paper appears white on a dark ground; whilst in the picture all the lights appear as shades, and the shades as lights. Such prints are called *Negatives*, and wherever this interchange of blacks for whites or lights for shades occurs, the result belongs to this class. If, however, we again print from these, the dark ground or shades protect the surface they are laid on, and they then resemble the originals; such are called *Positives*, and this term is applied in all cases where the lights and shades are represented as in nature.

When we are operating on transparent media, this power of reversing natural effects is of the greatest value, as it presents us with the means of obtaining what is analogous to engraved plates, from which we may print numerous copies, having all the effects true to nature; and it is to this circumstance that the Collodion Process offers such advantages, on account of the transparency, together with the modulations and depth of tone of the reversed or *negative* pictures obtained.

It is to the production of Collodion *negatives* in their application to natural history and anatomical subjects, and the method of printing *positives* from them, that I devote the following description of the various operations; and although these are described as when conducted under the most favourable conditions, this course is preferred, that a guide may be given to others as to the general principles of the arrangements necessary, but which may be modified according to the position and circumstances under which they may be placed, or the extent to which they may feel inclined to carry their experiments.

ENGRAVING, OR TAKING THE NEGATIVE.

The Operating Room, wherein the negative plate is taken, should be situated at the top of a house in a clear atmosphere; if possible, it should command a northern and southern aspect: where, however, only one aspect can be obtained, the northern is preferable, as it is exempt during the greater part of the day from the direct rays of the sun, and the actinic action over different times of the day is more uniform from this direction. This is divided into two compartments,—one, being the light room, contains the Object Table, the Background and Indicating Frame; the other, the dark room, contains the Camera, the table, sink, and necessary materials for coating, developing, fixing, and washing the plate.

The Light Room is built of glass, with the exception of a skirting, which rises about two feet from the floor. Within the panels are fixed rollers with black and white blinds, arranged so as to give the operator a thorough command over the direction and amount of light admitted, as may be readily understood by reference to fig. 1.

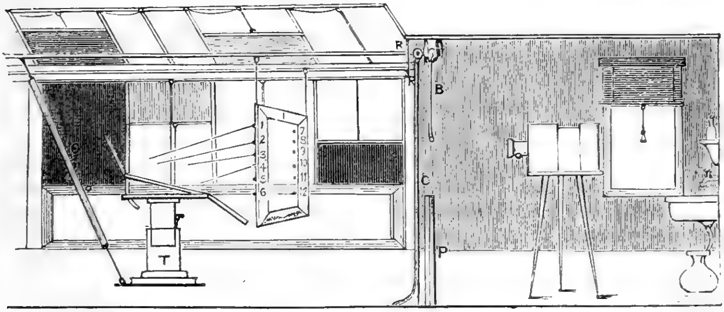

Fig. 1.

The Object Table I have planned (T, fig. 1,) is so contrived on a cylindrical pedestal, that the object can be raised and lowered, or turned to one side or the other, with facility, so that different parts can be arranged at any angle that may be required, as when taking an anatomical view from a dead subject.

The Back-ground (G) usually consists of a short-napped blanket, or a piece of nankeen cloth stretched on a frame. This is suspended by rings on the rods R R, which run across the sides of the room, so that it admits of being adjusted at any distance from the object; it may either hang perpendicularly, or gradually slanting from the object, which gives the appearance of a receding background to the picture. The best effect, however, is produced by using a very long and rough napped blanket, placed from three to five feet behind the object; and whilst the picture is being taken, swinging it from right to left by means of a cord attached to the frame: this produces a clear transparent background, which throws the object out into bold relief with excellent effect.

The Indicating Frame (I, fig. 1) I have contrived, consists of a broad, flat, black wooden frame, on the sides of which are painted white letters or numbers, and a fine wire, having free movement, corresponds to each letter or number, so that, if its end is dropped on any particular part of the object, we can refer to it by giving the letter or number at its origin on the frame; any other lettering, as the name of the object or that of the producers of the negative and positive, may be neatly written in with a chalk-pencil on the upper or lower bars. The top and bottom bars can be removed and replaced with others of different widths, so that the frame may be increased or decreased in width at pleasure. This is likewise suspended from the rods R R, and is so adjusted that the object is seen through it whilst the frame itself occupies the margin of the picture. By this arrangement the *positive* print gives a counterpart to which the type of the work it illustrates refers, and at the same time gives a finished appearance to the picture, whilst it also saves the expense and trouble of afterwards engraving the references, &c. on the plate.

The Dark Room is separated from the light by black curtains C, which can be drawn from each side towards the centre, by the partition P, and a black blind B, which draws down, so that the room may be made impervious to white light, when the picture is to be made sensitive or developed. At other times the curtains and blinds are drawn together so as to cut off the light which comes from beyond the margin of the Indicating Frame. A window of glass, stained yellow by oxide of silver, or common glass with two or three folds of yellow glazed calico strained over it; or, according to Mr. Wilkinson's observations, a window may be made of sheet India rubber, about 1-32nd part of an inch in thickness, is placed at the side for observing the development of the negative. The yellow media being employed to cut off the actinic rays from the light admitted, which would otherwise affect the sensitive plate. The sink is lined with gutta percha and drains off into a carboy placed for the reception of the washings, which contain silver, and are worthy of consideration in the economics of large photographic establishments; the water being at convenient opportunities evaporated off, the residue should be preserved, till a sufficient quantity is collected, to reduce the silver it contains, or convert it into a useful salt.

The Camera, or dark chamber, is usually constructed of well seasoned walnut-wood, in a manner similar to that figured above.

It consists of a base-board *A* (figs. 2, 3), 18 inches long, to the under surface of which are screwed three brass plates *B B B* (fig. 3): to these the spring legs, hereafter described, are attached. To guard these plates and the clamp-screw *I*, a stout bead, about 1½ inches deep, runs round the margin of the board, and is planed

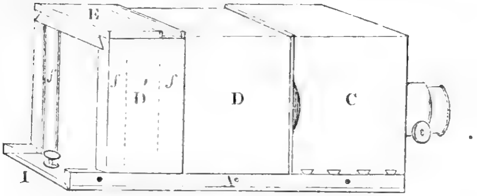

Fig. 2.

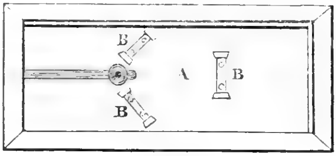

Fig. 3.

so as to stand perfectly true on any level surface. To the base-board is attached the front of the camera *C:* this is square and 6½ inches long laterally, into this slides D, the telescopic part of the back of the camera, which is 6 inches long. This should fit with great accuracy, that it may move smoothly and not admit any light into the interior. D′ is the part that receives the focussing glass and plate-holders; laterally it is 4½ inches long; in other respects it corresponds with the dimensions of the front of the camera *C*. The top of this portion, *E*, is only about 3½ inches wide, and is moveable, sliding in two horizontal dovetail grooves in the sides of D′, leaving an aperture for the reception of the plate-holders, either at the back or towards the front of D′, according as to whether it is pushed in the direction of the lens or drawn from it. *f f* are perpendicular grooves in the sides of D′, into which the focussing-glass and the plate-holders are accurately adjusted, so that the plates and the ground glass may occupy exactly the same plane. By this arrangement, together with the rackwork movement of the lens, a range of foci, varying from 5 to 18 inches, are obtained. The replacement of the ordinary trap by the sliding trap E, I have found advantageous.

In the front of *C* are two perpendicular dovetailed grooves, *G G* (fig. 4), into which slides the board carrying the lens F, which can be fixed by means of the clamp-screw *H*, at varying heights. This movement of the lens allows the image of the object to be centered on the focussing glass without disturbing the parallelism of the camera to the object itself, as otherwise it would be necessary to resort to the objectionable mode of tilting the camera, to obtain a proper distribution of fore ground. The interior of the camera is usually blackened, but M. Laucherer states, that by whitening it, he has found the time of exposing the plate lessened, and that there is greater uniformity in the distribution of the lights and shades in the pictures obtained; but this method has been found by others to be objectionable.

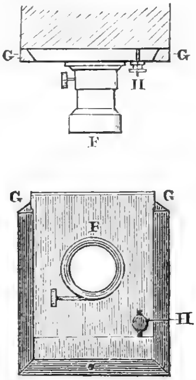

Fig. 4.

The Focussing Glass consists of a plate of ground glass fixed into a frame of wood about 1 inch in thickness, in such a manner that when the frame is dropped into the grooves *ff*, it shall *exactly* coincide with the position the prepared surface will occupy in *the plate-holders* when placed in the same grooves; in other words, both focussing-glass and sensitive surface must be equally distant from the lens. The ground glass is ruled with squares and circles in pencil to correspond with the sizes and show the position the various sized plate-holders occupy in the camera; and in focussing, the image of the selected portion of the object is made to occupy that sized circle which corresponds with the size of the plate on which the picture is to be taken. When the focussing glass can be used in the front grooves, the back part of D′ serves as a shade whilst obtaining a sharp image of the object. In focussing, the rough adjustment is obtained by means of the telescopic movement of the camera; the fine adjustment, by the rackwork or sliding movement of the lens.

After a satisfactory image is obtained, the back part of the camera is clamped by means of the screw I, which runs in a slit in the base board.

The Plate-holder consists of a wooden frame (fig. 5) K, about 1 inch thick, which exactly fills up the aperture that may be made in either the back or front part of D′, and the grooves *f f*, into which it slides. Into this frame may be fitted two glass-plates,* between which sensitive paper is placed; or these may be replaced by various

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* This or any other glass that may be interposed between the light and sensitive surface should be tested, according to Professor Stokes's recent experiments, to see if it be of a kind that will cut off the actinic rays of the spectrum.

plate-holders suited for the different sized plates. These are made of oak slabs, of the thickness of the *two* glasses, having apertures cut through them suited to the size of the plate they are intended to hold, and of the shape shown in fig. 5. Across the angles of these apertures are let four pieces of black glass, *M M M M*, of the same thickness as one of the glass plates. On these corners is dropped the prepared glass or metal plate, N: the sensitive surface thus occupies the same plane as paper would between the glass plates. A sectional view of glass and wood plate-holders is given in fig. 5, the references being the same as in the back view. In vertical side grooves, and in front of the holder and plate, works the slide or shutter of the frame *O*: this is hinged, so that when it is drawn up, it may be bent over the camera so as not to be in the way whilst operating. A door hinged into the side of the frame, closes in the plate; to the centre is screwed a spring, which presses the plate up to the proper position when the door is closed and hasped.

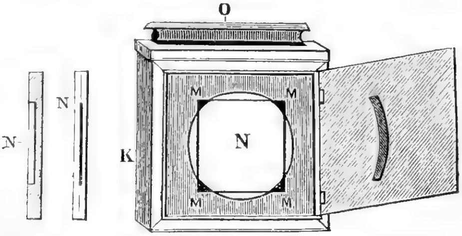

Fig. 5.

Cameras are constructed in various ways, so as to render them simpler and cheaper, or more complicated and costly, but the form described is a very good type of what a working camera should be. What are called hinged portable cameras are just costly refinements, excepting where lenses of long focus or that cover a large field are employed, for as a certain space must be occupied by the chemicals and apparatus, &c. required for the various operations, this may just as well be arranged for in the interior of the camera, which then serves as a packing case, and is ready for use as soon as the box containing the materials is removed from it. If the form of the camera described is used for travelling, a handle should be let in flush with the top of *C* (fig. 2).

The Lens.—Photographic lenses are of three kinds, the single—the single combination—and the double combination,—which are selected for use according to the nature of the object to be taken.

The desiderata in a lens are, sharpness of definition over the whole of a *flat* field, *depth* of definition, coincidence of the plane of chemical or actinic focus with that of the visual; in other words, the lens should be free from spherical or (relatively) chromatic aberration—I say relatively, for *photographic* lenses are not absolutely free from chromatic aberration, for part of the thermotic and the actinic rays are combined, those rays of the spectrum which produce the visual effect being present in the focus and in the same plane with those which combine to produce the *actinic* effect, whilst lenses intended to be used *visually* combine only those rays which have the greatest intensity in producing *light*.

As the term "*achromatic*," in relation to the correction of photographic lenses, involves an erroneous idea, Mr. Hunt has lately proposed the term "*diactinic*" for those bodies which are transparent to the chemical rays, and "*adiactinic*" for those which are opaque to them.

Spherical aberration is attributable to the incident rays *M* (fig. 6) not being equally refracted through different parts of the lens, the rays nearest the axial ray being less refracted than those nearer the marginal rays *M*, consequently they are collected at different foci, as is shown in fig. 6; the result being a confused image of the object on the focussing glass, bright and sharp in the centre, but gradually passing off into a hazy halo towards the edge. This is dependent on the form of the lens—the greater its convexity, or the greater the inequality of the curves on its two faces, with reference to the direction of the incident rays, the greater will be the spherical aberration: it is therefore less in a lens of periscopic form, which renders the marginal rays longer than the axial rays when the concave side is presented to the object.

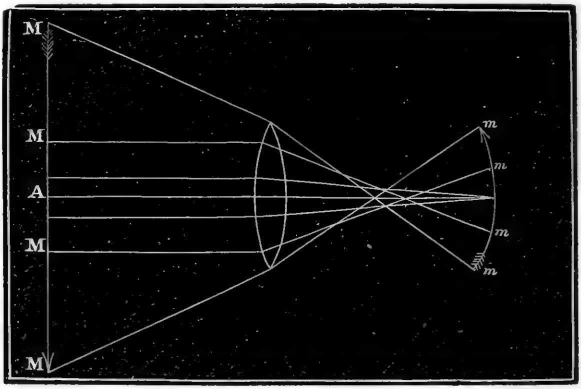

Fig. 6.

Spherical aberration is still further corrected by placing a *diaphragm*, or *stop*, at such a distance before the lens that it will just admit the rays of light from the object and thus exclude the marginal rays, as in fig. 8. In proportion, however, as we decrease the size of the aperture of the stop, we increase the sharpness of the image and the size of the field, but the operation of exposing the sensitive surface is prolonged in consequence of the amount of light thus cut off. This decrease of actinic power, by the use of stops, is generally in the proportion of 1, 4, 8—thus, *cæteris paribus*, if with the largest aperture a picture was given in one minute, the smaller aperture would require four minutes, and the smallest eight minutes, to produce the same effect.

Chromatic aberration is dependent on the unequal refrangibility of each of the coloured rays into which white light is decomposed whilst passing through the refracting substance of a lens.

As the red rays of the spectrum are least, whilst the violet rays are most strongly refracted, it is evident that the violet or *actinic* rays, A, will be collected at a shorter distance from the lens than the red, or *thermotic* rays, T, as is shown in fig. 7. The space between *A* and T constitutes the *chromatic aberration*, and within it are situated, at various points, the intermediate rays of the spectrum. At the point of intersection of the violet and red rays is situated the yellow or *luminous* rays and point of *visual foci*, L L.

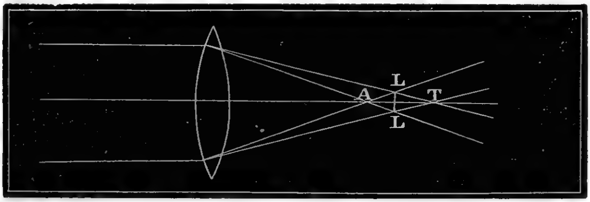

Fig. 7.

If therefore we obtained a sharp image on a focussing glass placed at L L, it would be necessary to place the sensitive surface, at A, to obtain a photographic picture with an uncorrected lens: this difference between the chemical and visual foci, in a single crown glass lens, usually amounts to about 1-27th of its focal length.

A simple mode of testing whether the visual and chemical foci are coincident, or the amount of aberration between the two, so that, in case of non-coincidence, the proper photogenic focus may be indicated, is by placing the camera before a flight of miniature steps, numbered on their faces from 1 to 7 consecutively, then focus for number 4 the centre step, take a photograph of the steps; if 4 appears sharper than the other steps or numbers, the chemical and visual foci coincide; on the other hand, if a number nearer to the plate is most distinct, the chemical focus is shorter than the visual, which indicates that the glass is under-corrected; if a number further from the plate is most distinct, the chemical focus is longer than the visual, which indicates over-correction, and the photogenic focus will then be behind instead of before the visual focus.

When lenses are used that have not these two foci coincident, a scale indicating the variation between the chemical and visual foci at different focal lengths should be marked on the draw-tube of the lens or the telescopic part of the camera.

Chromatic aberration is corrected in single lenses by the form of the lens, the meniscus being the best, and by cutting off the marginal rays, in which chromatic aberration is chiefly resident, by means of a stop, S, as is shown in fig. 8.

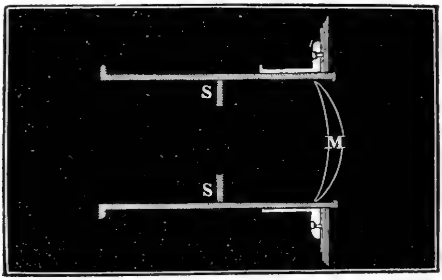

Fig. 8.

The most effectual mode of correcting chromatic aberration is by combining two lenses of media possessed of different refractive and dispersive powers. This is usually effected by employing a double convex lens of crown glass, the refractive power of which will place the focus of the violet rays at *v* (fig. 9), and the red rays at *r*, and a plano-concave or double concave of flint-glass, the refractive power of which would place the violet rays in focus at *v′*, and the red rays at *r′*, the result being the recombination of the various rays into white light, and the production of an achromatic image at a mean point dependent upon the focal lengths of the two lenses.

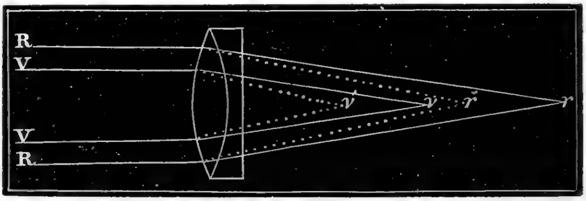

Fig. 9.

The *perfect* correction of the chromatic aberration is solely dependent on the proper ratio of the curves of the flint to the crown glass lens, and, according to Mr. Ross's experience, *diactinism* can only be determined by trial with each individual lens.

The experiments of Professor Stokes, Malaguti, and Sir John Herschel, warn us that care should be taken in selecting for the construction of photographic lenses such glass and cements as will not impede the actinic rays.

A *refractive aberration* is common to many lenses producing images wherein straight lines are represented as bulged inwards or outwards. This defect is generally confounded with spherical aberration: whereas it is dependent on the *media* of the lenses refracting more strongly at the marginal than at the central part of the lens, consequently bending *outwards* those portions of a line which are nearest the margin, and producing a pincushion shaped image of a square, or *inwards* producing a barrel shaped image of a square, according to the form and position of the lens.

As the *single lens* is slower in action than the double combination, but as it gives a larger field and greater *depth* of definition —by which term is meant the power of a lens to take in near and distant objects with equal distinctness [*]—it is therefore best adapted for landscapes and immoveable objects, as time, which is then of no object, can be allowed for bringing out the detail of the picture.

Fig. 8 represents the section of a single lens or objective, which is used on account of being cheaper, and taking in a larger field.

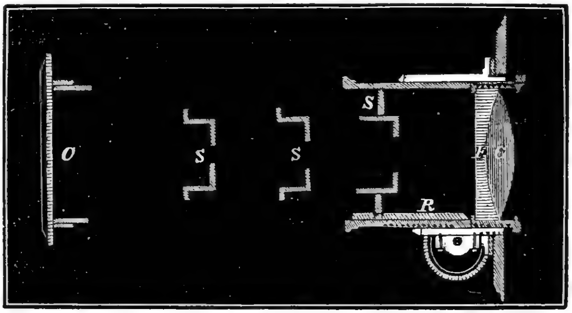

Fig. 10.

Fig. 10 represents *a single achromatic lens*, in section, constructed according to the principles of correction described, with stops S; cap, O; and rackwork adjustment R.

With *the double combination lens* (fig. 11) two corrected lenses are employed; and the aperture or diameter being greater in pro-

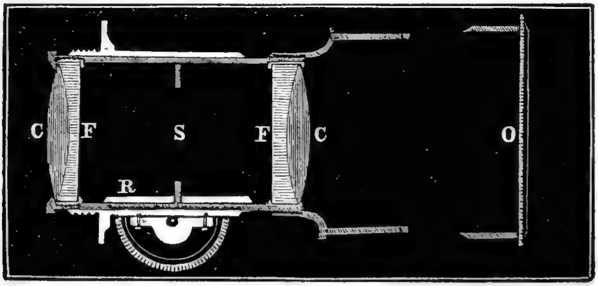

Fig. 11.

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[*] The best instance I have seen of this is in Pretsch's view of Vienna, taken by a Ross's lens, and exhibited at the late Photographic Exhibition at the Society of Arts. On the front of a house, situated about *four or six miles distant* from those in the foreground, the name of the occupant is discernible.

portion to the focal length than in the single lens, it is more intense and quicker in action, therefore best adapted for taking portraits, pictures of animals, and other moving objects, though the image is considerably reduced in size. The references S, O, R in this sectional diagram correspond with those in fig. 10.

Microscopic Objectives usually consist of three, sometimes only two compound lenses; but as they are over-corrected, the chemical and visual foci do not coincide, therefore must be compensated for. As it is important that the sensitive surface should be parallel to the object-glass, and having found difficulty in centering the body of the microscope to the camera, according to the mode recommended by Mr. Delves and Mr. Shadbolt, I have adopted the arrangement shown in fig. 12: a piece of tube is screwed into the flange of my photographic lens, and into a plate with which one end is closed, is screwed the object-glass; over this tube smoothly slides another, likewise closed at one end, but having an aperture corresponding to that of the lens: to this is attached a piece of metal, on which slides the clamping slide-plate, removed from the stand of my microscope; or two springs may be screwed to the front of the outer tube, the purport of either being to hold the microscopical slide or object. A scale, showing the difference between the chemical and visual foci, should be marked on the inner tube. With high powers a lever fine adjustment is necessary. To those photographers who have not microscopes, this will be found an economical mode of adapting lenses to their cameras, as the stand of the microscope is dispensed with.

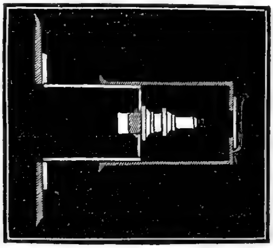
Fig. 12.

The Stand, in its simplest form, is made by fixing three spring legs, of the construction shown in Fig. 13, into the brass sockets B B B (Fig. 3), and thus forming a steady tripod, which allows the Camera to be easily adjusted in any position, and combines the advantage of extreme portability. There are many other forms more expensive or less portable, but which have advantages under some circumstances. Amongst the latter is the stereoscopic camera stand, which admits of that instrument being fixed at different angles.


Fig. 13.

Arranging and Focussing the Object.—The proper position of the object can only be learnt by experience, as it depends upon an artistic appreciation of the arrangement of light and shade, combined with a perfect knowledge of the chemical effect of light when radiated from surfaces of different colours. In anatomical subjects flaccid muscle should be padded up with cotton wool into a natural appearance of rotundity, the distinction between veins and arteries being obtained by employing coloured injections possessed of different actinic actions; and all parts that do not tend to a clear idea of the object should be cleanly cut away. A dark drab cloth should be thrown over the Object Table, to cover its mechanism, and to form a background to the object. After the object has been satisfactorily displayed, the indicating wires should then be adjusted to any parts that are to be specially described. Skeletons may be suspended from the rods R R (Fig. 1) by cords, or supports, *of the same colour as the background*, to prevent their prominence in the picture. Shadows of window bars, &c., must never fall across the object. Living animals should be taken at favourable moments, as when dozing in a standing posture, or on the look out for food; if wild, they should be induced to one end of a long, well-lighted den, whilst the lens is inserted between the bars at the other. Birds, reptiles, and some animals of a torpid nature, form very favourable subjects for operating on. It should always be endeavoured to get all parts of the object in as nearly the same plane as possible; if this cannot be attained, a small stop must be inserted to obtain greater *depth* of definition with the lens, to prevent distortion of the natural proportions. The light should fall in parallel rays on the object, and the Camera placed directly opposite it, and in such a position that strong rays of light do not fall upon the lens or intervene between it and the object. The lens should be adjusted so as to be *perfectly parallel* with the object; and if this is near, and inclines backwards from a plane vertical to the lens, a plate-holder working on an axis may be adjusted to a position parallel with the object.

A simple mode of ascertaining whether the Camera is level is by placing a marble on its top; when level, of course the marble will not roll in any direction; this likewise applies to the levelling stands. When, by focussing, a sharp image of every part has been obtained on the ground glass, the Camera is clamped, or, if working with an uncorrected lens, the variation between the two foci must first be allowed for. If a stereoscopic view of the object is to be taken, the Camera may be moved round about six degrees, to one side of a line central with the subject, and a particular part focussed on a fixed spot of the ground glass; the camera is then moved round to a corresponding degree on the other side of the central line, the same distance from the object being preserved, and the same part again focussed on the same spot. The two Photographs, taken at different points of view, when viewed in juxtaposition stereoscopically, resolve themselves into one image, with an appearance of solidity and elevation.

With microscopic objects beautiful effects of light and shade may be produced by the employment of polarized light, as the varying thickness of the object (as in crystals of urinary salts, &c.) produces colours of different *actinic* action; and with a Darker's selenite stage great command may be obtained over the colours desirable for producing the best effects by this mode of arrangement.

Cleaning the Plates.—Perfect cleanliness being of the *utmost importance*, when the plates are first received from the glass warehouse they should be immersed in a bath of liquor ammonia and water in equal parts, that all traces of grease may be removed, or, if they have been previously used with iron developing solutions, they should be treated with a bath of two parts nitric acid to one of water, and afterwards *thoroughly* rinsed with pure water. A convenient form of trough for these cleansing operations may be made of gutta percha, the sides being grooved for the reception of each plate separately, so that the liquid may have free access to both surfaces of the plate. To suit plates of different sizes, a moveable grooved slab may be fitted to move across the centre of the trough, so as to advance or recede according to the width of the plates; as soap contains grease it should never be employed. On removing the plates from the water they are wiped with a perfectly clean linen cloth, then laid on a flat metal plate,* and polished off with a silk handkerchief, a circular motion of the hand being used: they are then put away in the stock box till required. Before coating the plate with collodion it should be finally polished by rubbing it on a doe-skin buff, about ten inches long by four wide, and then dropped into a wooden bowl, to prevent contact with any unclean surface. To preserve the buff from dust it should have a hinged cover, only to be kept open during the operation of polishing. The moment before applying the collodion the surface of the plate should be lightly wiped with a cambric handkerchief to remove any trace of dust.

Glass Plates.—The glass plates on which the negatives are taken should be of the best patent plate, about $\frac{1}{8}$ inch thick, perfectly free from any irregularity of surface, and cut to fit the pressure-frames best suited to the size of the page to be illustrated, and the edges then ground.

Iodized Collodion is a preparation of gun-cotton dissolved in a mixture of anhydrous ether and alcohol, and iodized with pure and white iodide of ammonium, or what is better, as it keeps longer and is more conveniently applied, the iodide of silver and ammonium. By varying the proportion of the alcohol this may be made to produce films of different thicknesses and degrees of tenacity. The greater the quantity the quicker and more even is its action; but, if too much is added, it becomes attenuated, and then cracks and parts from the plate. If the film is to be transferred to paper,

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* The metallic surface prevents the accumulation of any electricity produced by the friction of the silk, which otherwise would attract floating particles of dust.

blocks or plates, it must be of a very stout quality. The neck of the bottle containing the collodion must always be freed from deposit before pouring any out.

Coating the Plate.—Bend the forefinger of the left hand into an angle, with the tip pressing on the ball of the thumb; on this rest the corner of the glass plate numbered 1 in the annexed figure, and hold it firmly with the end of the thumb; breathe on the glass to see if it is sufficiently clean and dry; if so, the vapour will pass off instantly; give it the final wipe with the cambric handkerchief, then bringing the glass into a horizontal position, pour the collodion plentifully on to the centre of the plate; incline the plate so that it will flow smoothly and gently into the corner marked 1, avoiding the thumb, then into 2, then 3, and lastly 4 (if the film appears too thin, it may be again flushed up to 2, allowed to spread over the plate, and again returned to 4), when, without touching the neck, return the superfluous collodion to the bottle, bring the plate into a vertical position, and impart a tremulous motion to the plate along the direction of its longer axis, so that the ridges formed by draining may run into one another: pass the lip of the bottle along the edge from 1 to 4 and from 4 to 3, backwards and forwards several times till all superfluous liquid is drained off: the result should be a perfectly smooth and even film. When the collodion is sufficiently set, and which can only be judged of from experience, it is ready for exciting.

The Sensitive Bath.—A gutta percha trough 1 inch across, and about the dimensions of the largest plate of your camera, is usually used for the sensitive solution, and should be fixed *obliquely* on a block of wood, not perpendicularly as is generally the case, for this position facilitates the insertion and management of the plate. I, however, prefer the glass trough adapted to the camera, which holds the bath in a position coincident with the focussing glass, as this arrangement certainly facilitates and shortens the operation. In either case a glass dipper may be used, which is simply a strip of glass with another piece cemented across it, on which the plate rests.

The trough is charged nearly full with a bath, which may be prepared according to Mr. Hennah's formula, in the following proportions:—

Nitrate of silver	40 grains.
Distilled water	1 ounce.
Alcohol	25 minims.

Separate about an eighth of the quantity prepared, and to the greater bulk add, drop by drop, a solution of iodide of potassium till a precipitate of iodide of silver is formed; agitate, and allow it to stand for some hours till the precipitate is dissolved; filter, and then add the portion previously set aside; test with litmus paper, and if the bath is neutral add nitric acid, in the proportion of two drops to the pint—

prepare rather more of this solution than is absolutely required to fill the trough. When by use this bath is robbed of its proper proportion of nitrate of silver, it may be again restored to its former strength by the judicious addition of a saturated solution of that salt. When not in use, it should be kept in a bottle; if in use, a lid fitted into the mouth of the trough, or the bath-frame of the camera, will preserve it from dust. When the temperature is below 60° Fahr. the bath should be raised to this point by placing it in a water-bath or by warming the room. The operating room, during the process of exciting the collodion film, must be preserved from the admission of white light, and yellow light only employed. The coated plate is rested on the dipper, previously moistened to promote adhesion, and with one steady plunge is passed into the bath. If there is the slightest pause, a line will be produced across the film, which will be imparted to the *positives* printed from it. After remaining in the bath for about a minute it is lifted in and out two or three times, and when the liquid flows evenly over the film it is sufficiently saturated; it is then drained, the uncoated side laid on a pad of blotting-paper to remove superfluous moisture, and finally adjusted in the plateholder, with pieces of blotting-paper interposed between the corners of the plates and the glass rests (M, M, M, M, fig. 5). If the glass bath adjusted to the camera is employed, the plate may be coated in the open air; and when the collodion is in a proper condition, the plate, resting against the sloping back of the bath, is plunged in, and the lid of the bath-frame shut down: in two minutes raise the lid and push the plate up to the front glass of the trough, so that it occupies a position corresponding with the plane of the focussing glass, and again close the lid, taking care during this movement not to allow any light to fall into the bath, which may be obviated by throwing a black cloth or yellow handkerchief* over this end of the camera.

Exposing the Plate.—If operating in the rooms described, pull up to the required height the blind that shuts off the light from the room containing the object, and see that there is a sharp image on the focussing glass; then fit the cap on to the lens, replace the focussing glass with the plateholder or bath-frame, raise the shutter of the frame (O, fig. 5), remove the cap of the lens and expose for the necessary time, replace the cap, close the shutter, remove the frame, and proceed to develop the picture as soon as possible. The requisite time for exposure can only be judged of by experience, as it depends upon a knowledge of the action of the lens employed, whether single or double combination, the size of the stop, the sensitiveness or age of the collodion, and the nature of the light, colour of the object, and the temperature of the atmosphere at the time of operating; but it varies from a moment to a quarter of an hour. With a single achromatic lens, of 12 inches

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* A large yellow pocket-handkerchief will be found a very useful companion to a photographer when on a tour.

focal length, 3 inches diameter, and ½ inch stop, from 10 to 30 seconds will be, however, on an average, found sufficient. If a negative is required, it must be exposed longer than for a positive.

Developing the Negative.—On removing the plate in the darkened room no picture will be visible; if it has been exposed long enough for the production of a negative, develop the latent image with the following solution:—

Distilled water . . .	8 ounces.
Glacial acetic acid . . .	4 drams.
Pyro-gallic acid . . .	12 grains.

If there is any sediment after the pyro-gallic acid has dissolved, filter and preserve it in a bottle. Place the plate on a stand, having an arrangement of screws by which it may be brought to a level; or the plan I employ saves the expense of this stand—across a glass plate, about 6 inches by 4, I cement a thicker strip about 1½ inch from one end, to prevent the liquid flowing up to the fingers and staining them; round the longer end I fold a piece of stout blotting-paper like a note; when this is moistened it acts as a sucker when the plate is laid on it, and may be moved about by the hand without fear of its separating. Having, by either of these means, brought the plate to a horizontal position, pour out, into a perfectly clean glass measure, a quantity of the developing solution sufficient for the size of the plate, and for every dram add 2 drops of a solution of nitrate of silver in the proportion of 40 grains to 1 ounce of distilled water.

A plate	4 inches	by	3	requires	2	drams.
,,	5	,,	4	,,	4	,,
,,	6	,,	5	,,	7	,,
,,	8½	,,	6½	,,	12	,,

Pour this over the surface, and if the plate is held on *the sucker* impart a gentle whirling motion to it, that a perfect dispersion of the liquid may be facilitated. The lights of the picture should appear first, and then the shadows, according to their depth of tone. Examine the progress of the development by reflected light, and when the details of the original are well defined pour off the liquid, and wash in the horizontal position with a stream of cistern water poured gently over its surface. Never retain the solution on the plate after it has attained a dark brown colour; and if the plate has been under exposed, which may be known by the picture appearing very slowly, and by the lights deepening before the appearance of the shades, it should be washed off before the whites become opaque. If, on the other hand, both lights and shades appear instantly and about the same moment, with little difference of tint, the plate has been over exposed, and little can be done to make it useful.

Developing the Positive.—If a positive is required, the picture should have a shorter exposure in the camera, and be developed with the previous solution, to which a few drops of nitric acid has been added.*

Fixing the Picture.—Cover the surface of the plate with a saturated solution of hyposulphite of soda, and by daylight watch the absorption of the iodide of silver, when every trace of this yellow salt has been dissolved, well wash it, and leave a body of water on the surface of the plate for twenty minutes, maintaining it in a horizontal position throughout this operation.† After the plate has been washed several times (for it is important that every trace of the hyposulphite of soda be removed, or it will crystallize and spoil the negative, as it would fade during the exposure when printing from it), it is drained, and, when *perfectly* dry, varnished with amber dissolved in chloroform, which is applied in a similar manner to coating the plate with collodion ; the negative is then ready to print from.

MAKING THE PLATES READY FOR PRINTING.

For printing, negative plates are alone employed. The side coated with collodion is laid on the albuminized surface of the positive paper, pressure employed to bring them into close contact, and they are then exposed to the light till the proper depth of colour is obtained. The best form of pressure-frame is that sold by Newman, of Regent Street, as the pressure is very equally distributed over the surface, so that there is little danger of breaking the glasses, and is thus constructed. A very flat, strong, well-seasoned board, with a cushion of cotton-velvet, padded with layers of flannel, is attached to two strong bars, which again fit into a still stronger bar, as will be readily understood by consulting the back and lateral views (Fig. 14). This cross-bar carries a screw at each end, over which a frame, fitted with a plate of glass, about 3-8ths of an inch thick, and corresponding with the size of the cushioned board, drops, and which can be screwed down to any required pressure by means of the nuts fitting on to the screws.

In the ordinary way each subject is printed on paper, only a little larger than the size of the picture ; afterwards trimmed and mounted on paper ; but in the present instance it will be perceived that both views, together with the letterings, are printed on one sheet and by a single operation.

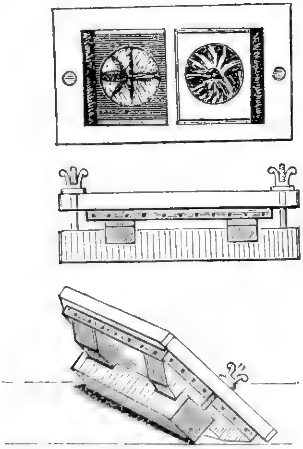

Fig 14.

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* See also Mr. Shadbolt's Paper, Micro. Jour., p. 169.

† A levelling stand may be readily formed of a gallipot and wedge of cork, placed in a dish or tray.

For the purpose of saving time (an important point in the application of photography to the illustration of periodicals or other works) I found it necessary to contrive a special arrangement to attain this end; and experience gained in working this out on the photographs illustrating this Journal fully justifies the adoption of this method for the future. In a stout board, ½-inch thick, square apertures, in proportion to the size of the page to be illustrated, are cut, just deep enough to admit a piece of plate-glass, ¼-inch thick, and the negative plate, so that when they are inserted together, the glass is flush with the wood; the thick plate, which is placed undermost, is rather larger than the negative, to allow of two beads fixing it down to the rabbet on which it rests; within the beads the negative plate is cemented by its edges, collodion film uppermost. Above this is cemented the lettering-piece, which consists of a strip of glass, coated and blackened by the albumen or collodion process, and then engraved backwards and varnished; this arrangement will be understood by examining Fig. 14.

If the negative plates are too large for the work they are intended to illustrate, as was the case in the present instance, being about 6 inches by 5, the best portion must be selected, the centre of this ascertained, and a circle scratched round it with the sharp point of the compasses; the plate is then cut down with a diamond to the proper sized square. If the object would appear to best effect with a black border, as in the figure of the Tracheæ of the Silkworm, the collodion film must be carefully trimmed away with a graver from the margin of the circle, then cleaned off with a cloth moistened with spirit, so as to leave the margin perfectly clear for the passage of light; this consequently prints black; on the other hand, when the subject is dark, as the Proboscis of the Fly, and would be thrown up with the contrast of a white ground, a circle must be cut out of black glazed paper, the aperture adjusted to the circle containing the part selected, and the margin gummed down to the collodion side of the plate.

Here I would suggest that if photography is found advantageous for the illustration of microscopical works, authors should adopt a plan similar to that found so convenient with object slides, of using a fixed scale of sizes for their glass plates, which must be determined by the sizes of the books they are intended to illustrate. A demy-octavo, with two negatives to the page, will only allow of the plates being 4 inches square; a demy-quarto will take in four of these plates, or two plates 5 inches square; a square octavo, one of the latter size.

As by this arrangement of the pressure-frame, both the objects and lettering-pieces are printed on the same sheet of paper at the same moment, labour and time, which otherwise would be necessarily employed in mounting them, are saved, consequently expense.

PRINTING THE POSITIVE.

ALBUMINIZED PAPER PROCESS.

The Positives, with which the present Number of this Journal is illustrated, are obtained by the albuminized paper process, which has been selected on account of the brilliancy of the lights, intensity of the shadows, and definition of the pictures it produces.

The Paper should have a smooth surface, a firm and even texture, weight from 12 to 24 lbs. per ream, of equal transparency throughout, free from spots of any kind; not too strongly sized,—a starch-sized being preferable to a gelatine-sized paper; as chemically pure as possible, free from watermark, and old paper should be selected in preference to new—the best papers for photographic purposes being those manufactured by Canson Frères, Turner, Whatman, and Lacroix.

The quality of a paper is ascertained by examining it vertically before a light, and *the side* to be chosen is that which does not show any small square indentations: this, being the smoothest of the two surfaces, is selected, and, for future recognition, should be marked in pencil with the letter R.

For the albuminized process Canson Frères' thick paper will be found the best, which should be cut in sizes, about ½ inch longer than the length of the picture required.

The Albumen. In a large-lipped basin mix the following proportions:—

The white of eggs - - - - - - - -	1 oz.*
Distilled water - - - - - - - - -	1 oz.
Chloride of sodium - - - - - - - -	½ oz.

Whisk this mixture up to a white froth with a wooden or ivory salad-fork, or, what is better, a bundle of three or four pens stripped of the feathers; then skim with a wooden or ivory spoon, cover it with a glass plate, and let it stand for twenty-four hours. The scum that is formed on the surface at the end of that time should not be removed, as it protects the rest from dust. Make a small hole in this scum near the lip of the basin, and gently decant a sufficient quantity to cover the bottom of a gutta percha trough to the depth of ¼ inch. The best troughs that I have seen are those sold by Henneman; they are stamped in moulds, and are attached to slabs formed out of two pieces of well seasoned wood glued together in reverse positions of the grain: this effectually prevents warping, and secures a very flat bottom. As the internal surface is polished, it should never be wiped out with anything but a piece of fine sponge, and when not in use should be kept filled with water. Remove any air-bubbles that may form on the albumen with a piece of paper, then take the paper by two corners diagonally opposite, between the tips of the fingers and thumbs; lay one corner on the albumen, bend

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* One ounce equals the white of one egg.

the paper backwards till it bulges out like a "squaresail" before the wind, lower the edge nearest the body gently on to the surface, and then, with an even and sweeping motion of the hand, carry forward the marked side of the paper over the surface of the albumen till it floats flat thereon, taking *great* precautions that air-bubbles are not interposed, and that the paper never touches the bottom of the trough, as in either case it would be spoilt; allow the paper to rest for two or three minutes, then with a reverse motion of the hand rip it off the albumen, allow it to drain from a corner, pin it by one corner on to a tape stretched across the room; in a few minutes make a small piece of blotting-paper adhere to the lowest corner to absorb all moisture that may drain into it; when dry, place it on three or four sheets of blotting-paper, and one sheet on the back; then pass an iron over it so warm that saliva just simmers on it. This coagulates the albumen, forming an insoluble size which renders the paper very tough.

Making the Paper Sensitive.—In the dark room is placed a gutta percha trough, containing a solution* of—

Nitrate of silver - - - - - - -	120 grains.
Distilled water - - - - - - -	1 oz.

on which the albuminized paper is floated for two or three minutes, and then dried in the same way and with the same precautions as in the former operations. When dry, the papers curl up into cones, like grocers' sugar papers, and in a similar manner may be packed one inside the other, and placed in a tin case till required for use.

If protected from white light, this paper will keep for about a week after its preparation.

Exposing in the Pressure-frame.—In the darkened room take the sensitive albuminized paper, spread it out flat, and adjust it on the cushion of the pressure-frame; place the board into which the negatives are fixed over it, so that the coated surface of the plates is in contact with the sensitive side of the paper; screw the two boards tight together, tilt the frame over into such a position that an equal beam of light falls upon the picture; if in the direct rays of the sun, expose for about three minutes; if in diffused light, from half an hour to one hour. The exact time for obtaining the tone required can, however, only be judged of by experience, as the depth of tone of the negatives operated with, and the amount and kind of light during the time of printing, must be taken into consideration. It is, however, better to over than under-print the positives, as the tone can always be reduced, but not increased, by after operations.

Fixing.—The positives must be finally fixed by carefully dissolving out all the remaining chloride of silver they contain by

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* This proportion may be considered extremely strong, but Mr. Henneman finds that it produces vigorous pictures with rapidity. The silver may be reduced to 100, 80, 50 grains, or less, but the chloride of sodium must be reduced in proportion.

immersing them in a bath of one part of a saturated solution of hyposulphite of soda and eight parts of water. The older this bath becomes the better are the tones obtained ; care being taken to add occasionally some fresh crystals of the hyposulphite to prevent its being saturated with the salt of silver obtained from the positive previously treated in it, in which case its dissolving powers cease.

Fixing and Toning.—Various tones, from India paper tints to pure black, may be given to the positives thus obtained, by treating them, after removal from the pressure-frame, with a bath of—

Hyposulphite of soda - - - - - - -	1 oz.
Water - - - - - - - - - - -	7 oz.
Chloride of gold - - - - - - - -	2 grains,

contained in a gutta percha trough, the positive being placed with the picture uppermost. By this method the positive is toned and fixed by the same operation.

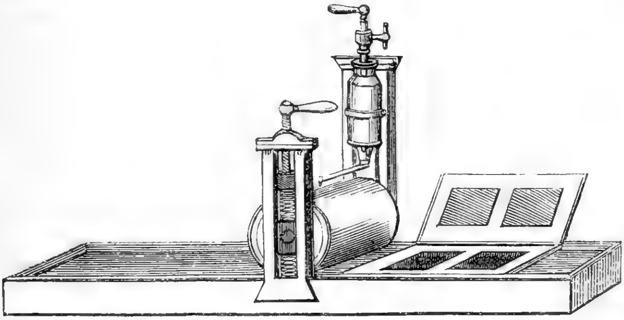
Watch the proof till the desired tone has been obtained, the positives should then be removed, and afterwards washed in a succession of baths of warm water till every trace of hyposulphite of soda is removed. These washings usually require about six baths of a quarter of an hour each, and then a final one in distilled water. Too great care cannot be devoted to this operation being thoroughly performed, as otherwise the pictures fade in the course of time.

On removal from the last bath dry the proofs by suspension ; when dry, smooth them out by passing a warm iron over the backs, or hot-press them ; the warmth also improves the tones of the picture, and glazes it.

Having placed before the reader the various stages of the collodion and albumen process, it will be readily understood what advantages the former offers, for whilst by its aid we can obtain faithful delineations of such an object as the Proboscis of the Fly, from the moment of coating the plate to its final varnishing, in less than a quarter of an hour, and at the cost of a few pence, the same subject engraved on wood, with an equal amount of minuteness, would occupy a wood-engraver a month, and at a cost of not less than ten pounds. On the other hand, the expense of the employment of silver salts, and the time required in fixing the positives, considerably enhances the cost of printing from them. I trust, however, that photographers will see the necessity of devoting their attention to the perfection of some printing process wherein cheaper sensitive materials can be employed, and probably some of the *chromates* would supply this desideratum : but such rapid and vigorous results have been obtained by the employment of the silver salts, that there has been little inducement to seek perfection by aid of other, though cheaper, agents. As yet the economics of the art have not come fairly before them.

Another cause, tending to make Photographic Printing expensive and inconvenient, is the entire dependence of the operator on favourable weather ; means should, therefore, be adopted to render him independent of natural light, and little difficulty would, I think, be experienced in arranging a diffused artificial light suitable for photographic purposes; and the aim should be to produce a bluish violet-coloured flame, not an intensely white or yellow one.

It will be seen that the photographer occupies the position of the draftsman, engraver, and printer of ordinary processes; but the analogues of drawing and engraving being performed at one and the same moment suggests a division of labour between the Photographic Artist, who would devote his attention to the artistic principles of the subject and the production of the negatives, and the Photographic Printer, who would conduct the processes for the production of positives; and this branch should be conducted on an extensive scale, with division of labour, but this not of an expensive kind, as children or girls might be employed with advantage; and, as mechanical means generally facilitate labour, a photographic press, of the following construction, might be employed. A flat board, with beaded edges, carries two upright supports for the axis of a glass cylinder, covered with a few layers of cloth; this is kept saturated with the sensitive solution by a reservoir attached to one of the uprights, the bottom of which is prolonged into a tube drilled with a row of holes, from which the liquid flows on to the cylinder according to the amount of atmospheric pressure exerted on its surface, which is governed by the admission of air into the reservoir, by means of a stop-cock attached to its neck. The paper is laid on a cushion, sliding between the beads of the base board, and a silver plate, with apertures corresponding to the size of the surface to be made sensitive, is brought down on it; it is then passed under the cylinder, which has previously been regulated to the proper amount of pressure, by screws affecting the springs on which its axis rests, the paper is then removed, and that part only which is to be acted on will have been made sensitive instead of the whole of its surface, thus preventing the absorption of more liquid than is necessary.



In many instances collodion films may, with advantage, be transferred to wood, metal, or stone, and thus save the draftsman's labours altogether. When metal plates, however, are to be engraved from photographs, the employment of the daguerreotype process would be more advantageous, the practicability of which has already been demonstrated in Donné and Foucault's "Cours de Microscopie complémentaire des Etudes Médicales," published as early as 1846.

In concluding this article, I beg to offer my sincere obligations to Mr. Delves for his liberal and valuable aid in furnishing, for this Number of the 'Microscopical Journal,' the requisite number of negatives from which the positive proofs were produced by Mr. Henneman of Regent Street; also to Mr. A. Ross and Mr. Henneman, for their kindness and readiness in affording me information on lenses and practical photography. And if, in describing the various operations, I have risked appearing diffuse, it is because I am convinced that success in these processes depends upon the minutiæ and niceties of the manipulations, but which, however difficult they may appear in type to the uninitiated, after a few trials will come readily to hand, and, with moderate attention, will be rewarded with success.

TRANSLATIONS.

On UNICELLULAR PLANTS *and* ANIMALS. By C. TH. v. Siebold. From Siebold and Kölliker's Zeitsch., f. w. Zool. Bd. 1, p. 270.

(Continued from page 121.)

Respecting the motions, which have been frequently noticed in unicellular Algæ, Nägeli observes very truly (p. 19), that they present nothing of a spontaneous or animal character, since they arise, not in the contraction or expansion of the membrane, excited by an external or internal irritant, but proceed singly from the vegetative processes of absorption and excretion of fluid, and the formation and solution of solid matters. Of the four categories of these plant-motions distinguished by Nägeli, we are here interested only in the third and fourth, since it is precisely those which have been confounded with animal movements.

The slow forward and backward movement, which has been observed in several Diatomaceæ and Desmidiaceæ, is explained by Nägeli (p. 20) in the following satisfactory way :—"The cells have no special organs for these movements. But as, in consequence of their nutritive processes, they take it and give out fluid matters, the cells necessarily move, when the attraction and the emission of the fluids is unequally distributed on parts of the surface, and is so active as to overcome the resistance of the water. This motion, consequently, is observed more particularly in those cells which, in consequence of their taper forms, easily pass through the water ; these cells, moreover, move only in the direction of their long axis. If one half of a spindle-shaped or ellipsoidal cell chiefly or exclusively admits material, the other half, on the contrary, giving it out, the cell moves towards the side where the admission takes place. But as in these cells both halves are physiologically and morphologically exactly alike, so it is that it is first the one and then the other half which admits or emits, and, consequently, the cell moves sometimes in one, sometimes in the opposite direction."

In this way may be explained, perhaps, all those motions, which are so readily noticed in the Bacillariæ. Only a complete misconception of these plant-motions could have induced Ehrenberg to seek for motile organs in these organisms. According to him, it would appear, for instance, that the

Naviculariæ can project an undivided motile organ like the foot of a snail from one of the central openings of the shield. This pedal organ is said to lie constantly closely applied to the shield, but to admit of its being extended as far as the two extremities. I have never been able to detect this organ in any Navicula, nor has Kützing, with his utmost endeavours, succeeded in the finding of it. As, on the other hand, Schmidt and Eckhardt (Wiegmann's Archiv, 1846, Bd. I. p. 212) have been more successful and have seen this remarkable foot, I can only oppose to this the following observations. Ehrenberg states, that in Navicula there are six rounded openings upon the dorsal and abdominal surfaces—four at each end and two in the middle. Of the four openings at the ends, the two on the abdominal surface are said to be oral openings, and the two on the dorsal, respiratory, whilst the central opening of the abdominal surface is stated to be for the protrusion of the foot. In *Navicula fulva* Ehrenberg supposes that a similar foot-like organ is protruded also from the dorsal opening. How Ehrenberg has been thus deceived I know not, but in contradiction to all these various erroneous notions, I can only say this much, that these six openings in Navicula have no existence whatever, but that precisely in the spots at which Ehrenberg and others suppose they have seen six openings, the siliceous cell-membrane is thickened and consequently forms so many rounded eminences which project internally. It is, therefore, needless to say, that there can no longer be any question about either oral or respiratory openings, nor of openings for the passage of a motile organ. On the same two surfaces, upon which the six round thickenings of the siliceous shield of Navicula are placed, there are observable, on the contrary, four lines, running along the middle of the surfaces from one thickening to the other. These lines, which have been long known, but hitherto apparently but little noticed, are to be referred to a suture, fissure, or rather gap, in which no siliceous matter is deposited, so that in these places the delicate primordial membrane which lines the siliceous shield can be brought in close relation with the external world. I come to this conclusion from the circumstance that it is exactly at these four sutures or fissures that the water surrounding the Navicula is set in motion. The existence of this current is readily demonstrated if some minute solid particles are added to the water in which are some fresh Naviculæ. Indigo is the best for this purpose. When water thus coloured with indigo has come to a state of rest on the object-glass, it will soon be perceived by the microscope that those particles of indigo which come in contract with the living Naviculæ are set into a quivering motion, although previously quite motionless. It will, moreover, be perceived that only that indigo is set in motion which is in contact with the four above-described sutures of the siliceous shield, whilst the particles of indigo adherent to the other parts of the shield remain altogether motionless. Besides the quivering movement, another very striking motion is perceptible in these indigo particles, which, when they come in contact with the sutures of the siliceous shield, are forced pretty rapidly up and down upon it. The indigo particles, which are propelled from the terminal towards the two central eminences, are never observed to pass beyond the latter; at this point there is always a quiet space, from which the particles of indigo are again repelled in a reverse direction towards the extremities. This proves that the linear sutures, as may in fact be seen, do not extend over the central eminences of the shield. The current at these clefts is occasionally so strong that proportionally large bodies are set in motion by it.*

These movements did not escape Ehrenberg, when he endeavoured to feed the Naviculaceæ with indigo, although he explained them erroneously, attributing the attraction and repulsion of neighbouring substances, in the case of Naviculæ, to the pedal motile organ. Moreover, that Ehrenberg had not apprehended these movements with full attention, is evident from the figures above cited, in which he indicates that the indigo on both surfaces of a *Navicula viridis* passes beyond the central eminence. It is to be regretted that Nägeli, in the paper here quoted, has not subjected the Diatomaceæ to any special investigation, from which we should undoubtedly have gained much information respecting these unicellular organisms.

The fourth sort of movement noticed by Nägeli (p. 20) in the unicellular Algæ is of most especial interest, viz. the "Swarming," which occurs in many Palmellaceæ, Protococcaceæ, and Vaucheriaceæ. He remarks very correctly that this "Swarm-

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* I will take this opportunity to remark that water coloured with indigo is an excellent means for the study of the remarkable plant motions of the Oscillatoriæ, which have heretofore been regarded as of an animal nature by various naturalists. These plants afford a very interesting sight when thus examined. The particles of indigo which come in contact with the single filaments of the Oscillatoria are propelled in a tolerably close spiral along the filament to its extremity. Whether the filament itself continues to move or is quiescent, it was equally striking to me to notice that occasionally this spirally gliding motion of the indigo took place from each end of a filament towards the middle, in cases where the colouring matter was agglomerated into a ball, or that this motion sometimes proceeded in a reverse direction from the middle of a filament towards each end.

ing" is a phenomenon identical with that observable in the sporangia of the multicellular Algæ (*Ulothrix*, *Conferva*, *Chætophora*, &c.). I must here, in passing, remark, that Nägeli, Thuret, &c., when speaking of "Swarm-spores," do not thereby understand any sort of moving corpuscles accidentally met with in the water, and arbitrarily taken for vegetable forms, just as similar corpuscles in the water have been arbitrarily considered as animals by Ehrenberg. These naturalists have rather observed the development of these Swarm-cells or spores within their mother-cells, in uni- or multi-cellular Algæ, and have distinctly satisfied themselves of the vegetable origin of these free-swimming corpuscles. In this way it was not left to the subjective judgment of the observer to decide, according to the impression he might receive, whether these corpuscles are plants or animals. Ehrenberg, therefore, is in error when he pronounces the Swarm-spores of Algæ, the development of which he has not observed, to be Infusoria; and Thuret is in no way to be blamed, as he is by Eckhardt (*op. c.*, p. 214), in his figuring moving bodies (supposed Infusoria), which, however, he saw developed in the cells of Algæ, and escaping therefrom, as spores of Algæ.

Nägeli (p. 20) thus expresses himself with respect to the Swarming of unicellular Algæ:—" It is usually the solitary individuals that swarm, rarely the families consisting of several individuals. The swarm-cells have, for the most part, an ovoid or short pyriform, rarely a spherical figure; they have at the narrower colourless extremity two or four, or a circlet of very delicate cilia, or are covered throughout with similar cilia. Under the microscope the motion appears very rapid, somewhat of an infusorial character, consisting in a continual progression, in which the hyaline, narrower extremity is usually in front, and the cell is continually turning on its long axis. Although the swarming bears a resemblance to the motion of Infusoria, it is clearly wanting in the spontaneity of the latter. The Infusoria advance, spring back, turn round, return, all spontaneously; the swarm-spores pursue (p. 21) a uniform and, for the most part, pretty straight course, deviating from it, or turning round only upon meeting an obstacle, impinging upon which they are diverted into another direction. Besides this, the wall of the swarm-cell, although extremely delicate, is yet impassive and motionless, whilst in the Infusoria, either the membrane is manifestly contractile, or its appendages (cilia) are motile."

I entirely agree in this representation and explanation of the "swarming in the unicellular Algæ, which is also entirely in accordance with what takes place in the multicellular Algæ, and have already so expressed myself (De finib. inter regnum animale et vegetabile constituendis. Erlangæ: 1843). Only I cannot concur with Nägeli when he makes a difference between vegetable and animal cilia, saying that the former, the delicate plant cilia, are rigid, or admit of only passive movements, whilst the animal cilia alone are said to possess the faculty of spontaneous motility. To this Nägeli adds (p. 22), that although it is true the cilia do move in otherwise entirely rigid swarm-spores, yet he denies that they are the cause of the motion of the swarm-cells, because there vibration is only the natural consequence of the current in the water produced by the active endosmosis and exosmosis of the cells. According to Nägeli absorption, is effected at the hyaline extremity corresponding to the root end of a plant, by which is explained the fact that the swarm-spore swims with that end in front, attraction being set up at that extremity, and repulsion at the other, owing to the resistance of the water to the fluids emitted. As far, perhaps, as the direction of the motion of the swarm-spore is concerned this explanation would account for it; but I very much doubt whether an end- and exosmotic process, however active it may be, would of itself account for the quick and often extremely rapid movement of these spores. The vibration of the cilia which, in my opinion, plays the principal part in the movement of the spores, is explained by Nägeli to be the natural consequence of the currents in the water, the cilia being so delicate as necessarily to be affected by the slightest fluctuations. In contradiction to this, however, I must remark, that the frequently rather long cilia are almost always extended, with a lashing motion, in the same direction as that in which the spores proceed; which could not be the case with such delicate and flexible organs unless they exerted a power of spontaneous motion. I cannot dispute, however, that the immotility and impassiveness of the vegetable cell-membrane, as Nägeli properly remarks, is a general law without any exception, but I am by no means satisfied, that from this motionless and impassive or rigid membrane are developed the motile cilia of the swarm-spores. With respect to this, however, Nägeli argues, that even the vegetable spermatic filaments have an impassive form, and advance merely in consequence of their turning around their axis. To this I would object, that the remarkable and very active motions of the vegetable spermatic filaments, according to the most recent discoveries of Thuret, Decaisne, and Suminski, are caused by two or several long motile cilia which are attached to one extremity of these entirely impassive spermatozoids.* In this we perceive an important distinction between the formation and movement of the vegetable and animal spermatic filaments, the former being self motile, whilst the latter are moved only by the aid of vibratile cilia.

It appears that Nägeli is inclined to raise a distinction between vegetable and animal cilia, principally because otherwise it would be necessary to assume the existence of *contractility* in the former. I would maintain, however, that neither the vegetable nor the animal cilia, between which I can perceive no difference, are to be regarded as delicate *contractile* filaments. In the actively-moving vibratile cilia particularly, as well as in the animal spermatozoa, the movements proceed in a way as yet altogether unknown; from a simple waving and bending action, unattended by any shortening or lengthening, and without any thickening or attenuation of the filament, whilst the delicate non-vibratile, but undoubtedly contractile (animal) filaments, during their movement become at the same time shortened and thickened, or elongated and attenuated. It is true that Unger describes, with respect to the ciliated organ of Vaucheria, a retraction and shortening of the cilia or spores, from the influence of a solution of sugar. But the result of this experiment in no way goes to show the contractility of these excessively delicate cilia, as it was not observed during their life, and must undoubtedly be considered as a process of decomposition; in support of this is the fact, as Unger expressly remarks that the coarser cilia, on the branchiæ of Unio, though, indeed, rendered motionless by the same treatment, nevertheless do not become shortened.

The movement of the swarm-spores in general have only a short duration. After the spores have come to a state of rest, they usually become attached by the hyaline-ciliated extremity, and the locomotive faculty is for ever lost. That these spores should move toward the light, cannot be wondered at when we consider the hungering after light so generally observable in the vegetable kingdom.

With respect to the motion of the spores, I must again remark upon a phenomenon above described by Nägeli, and which is one of a very evident nature, viz., that these bodies are impelled involuntarily, and proceed always in one direction, and without resting. If in this course they strike upon

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* *Vide* Thuret on Chara; Ann. d. S. Nat. Bot., tom. 14, 1840, p. 67, Pl. 7, and Decaisne and Thuret. *Ib.* tom. 3, 1845, p. 8, Pl. 1 & 2; on various fucoids. Suminski, Entwickelungs-Geschichte der Farrnkraüter. Berlin, 1848, p. 11, Pl. II.

any larger object, they do not retreat from it frightened as it were, as do the Infusoria not unfrequently, but they impinge directly upon the obstacle, remain close to it, and continue their motions, according to the number and arrangement of their ciliary apparatus, in a rotatory or vibratory way for a little time longer, as if they aimed at overcoming the obstacle by force, until at last, probably in consequence of the death of the cilia, they become still, and germination goes on, so that the swarm-spores belonging to certain multicellular Algæ make use at the same time of one and the same object as a basis, to which they become affixed by warty processes, projected from the hyaline extremity.

In several unicellular Algæ, particularly in those which "swarm" united into families, that process endures very much longer: in some species, indeed, the "swarming" families continue almost their whole life through in the same condition; this is the case in the Volvocina, in which, even during the "swarming," new "swarming" families are produced, or do not come to a state of rest until the period of [true] propagation has arrived.

How strikingly the swarm-spores, both of unicellular and of multicellular Algæ, resemble certain Monadina and Cryptomonadina is well seen in the representations of various spores of this kind, given by Unger, Thuret, Solier, and Nägeli. It is well known that Unger ('Die Pflanze im Momente der Thierwerdung,' 1843, figs. 8, 10) discovered that the motion of the spores in *Vaucheria clavata* was effected by a general ciliary investiture, a discovery which was confirmed by Thuret ('Recherches sur les Organes locomoteurs des Spores des Algues, Ann. d. Sci. Nat. Botan.,' tom. 19, 1843, Pl. II., figs. 29, 30). The same observer (ib., Pl. X., figs. 13, 14, 18) noticed a circlet of cilia in the "swarm-spores" of *Prolifera* (*Conferva*) *vesicata*, *alternata*, *tumidula*, and *Candolii*, as did Solier (Mémoire sur deux Algues Zoosporées, ib., tom. 7, 1847, Pl. IX., fig. 8-11 and 23) in *Derbesia* (*Bryopsis*) *marina*, and *Lamourouxii*. According to Thuret (ib., Pl. X., figs. 1-3 and 7-10), the zoospores of *Conferva glomerata* and *rivularis* swim about with the aid of two lash-like cilia, and those of *Chætophora elegans*, on the other hand, with four. Nägeli figures the zoospores of *Apiocystis Brauniana*, Näg., of *Tetraspora explanata*, Kütz., and *Characium Nägelii*, Br. with two such cilia. Fresenius (Zur Controverse über die Verwandlung von Infusorien in Algen, 1847, figs. 1-3) detected in the biciliated zoospores of *Chætophora elegans*, also the (so termed) red "eye." According to the highly interesting researches of A. Braun (Verhandl. der Schweizerischen naturforsch. Gesellschaft zu Schaffhausen, 1847, p. 20), a formation of spores occurs in *Hydrodictyon utriculatum*, in consequence of which, zoospores, with four long cilia and a red granule in the interior, swim about with great activity.

How extensively, again, these zoospores are present among the Algæ, is shown in the numerous researches of my friend A. Braun, here in Freiburg. I can here only refer to his memoir just quoted, which will show what an abundance of materials he has already collected on this important subject, and how interesting it would be to science were he to resolve to publish these discoveries in their whole extent. From the memoir above noted it is to be gathered, that in *Conferva glomerata* and *fracta* numerous spores, with two cilia and a (so called) red "eye" spot, quit the mother-cell, through an opening which is formed in a definite spot. In *Ulothrix zonata*, Kütz., he saw formed in each cell from eight to sixteen spores, furnished with four cilia and a large round "eye," which escaped through a lateral opening in the mother-cell, enclosed in a delicate vesicular membrane, and did not swim about until this membrane was ruptured. In *Draparnaldia mutabilis*, *Stygeoclonium tenue*, and several allied species, as well as in *Chætophora tuberculata*, according to Braun's researches, there is in each mother-cell only a single red-eyed spore, with four lash-like cilia. Braun, moreover, confirms Thuret's previous observations on other Confervæ, and describes also the propagation of the unicellular algan plant, *Characium Sieboldi*, Br., in the spindle-shaped mother-cell of which, sixteen and more spores with two cilia become developed; and also mentions a *Protococcus versatilis*, Br., the cells of which, after their attaining a certain size, divide into two motionless cells, which, by repeated segmentation, divide into four, and these, in like manner, into eight; which last—fourth generation—swims about for a short time by means of four vibratile cilia, in order eventually again to go through the motionless cycle of vegetation.

Another distinguished work, already several times quoted, 'Ralfs' British Desmidieæ,' also treats of unicellular plants, which have been confounded with lower animals, although in a more limited sense, embracing only the Desmidiaceæ and Closterina of Ehrenberg.

Respecting the remarkable process of segmentation, by which most of the Desmidiaceæ are multiplied, Ralfs remark (p. 5) that the segments gradually enlarge whilst they divide, but that this multiplication by division has its limits, for, after a certain number of generations, the individuals which had by repeated division attained a certain size, at last perish.

A most especial service has been rendered by the same assiduous observer of the Desmidiaceæ in his investigation of the process of *conjugation* in so very many of these unicellular plants. This process had been previously described by him (Ann. Nat. Hist., vol. xiv., 1844, p. 258, P. viii., and vol. xv., 1845, p. 153, pl. x.) in *Tetmemorus granulatus*, R., and *Staurastrum mucronatum*, R. In his recent work we learn that the same proceeding takes place, besides the Closterina, in many other Desmidiaceæ, viz. *Hyalotheca*, *Didymoprium*, *Sphærozoma*, *Euastrum*, *Micrasterias*, *Cosmarium*, and *Xanthidium*. In the moniliform *Hyalotheca dissiliens*, R., and *Didymoprium Borreri*, R., the conjugation takes place in such a way that two contiguous cells separate on the sides opposite each other, and through the cleft their contents escape in order to form a common sporangium. In the permanently unicellular forms of the Desmidieæ, with the exception of certain Closteria already mentioned, two closely approximated individuals dehisce transversely in the middle, and yield up their whole contents to the formation of a single sporangium.

The sporangia of the Desmidiaceæ thus originating in conjugation have for the most part a spherical form, and, according to Ralfs (p. 10), in many species remain smooth and unaltered, whilst in many others they become granulated, tuberculated, or spinous, many eventually acquiring a Xanthidian figure.

It is to be regretted that Ralfs and Jenner have not as yet succeeded in tracing the further development of the Desmidiaceæ within these sporangia. From the coloured figures in Ralfs' work, it appears that the green contents of the sporangia in certain Desmidiaceæ in time become red. Whether this phenomenon be connected with a further development of the contents, and perhaps corresponds with the transformation of the Chlorophyll into an orange-coloured oil, as described by Nägeli, I must leave undecided. [Here follows an abstract of Mr. Ralfs' excellent observations on the question of the vegetable or animal nature of the Desmidieæ; but as his valuable work is probably in the hands of, or attainable by, all who may feel an interest in knowing what such an accurate observer and careful reasoner says upon this subject, it seems needless here to give the abstract.]

A very important discovery recently made by Thwaites (Annals Nat. Hist., vol. xx., p. 1847, p. 9, and 343, pl. iv. and xxii.), showing that conjugation takes place also in the Diatomaceæ, cannot here be passed over. He observed in *Eunotia turgida* and *Zebra*, Ehr., as well as in *Epithemia gibba*, Kütz., and *Fragilaria pectinalis*, &c., the following remarkable phenomenon. Two individuals, closely approximated, dehisce in the middle of their long diameter, whereupon four protuberances arise, which meet four similar ones in the opposite frustule. These indicate the future channels of communication by which the endochrome of the two frustules becomes united, as well as the spot where is subsequently developed the double sporangium, or rather the two sporangia. The masses formed by the coalescence of the two portions of endochrome shortly become covered each with a smooth cylindrical membrane—the young sporangia. These gradually increase in length, retaining nearly a cylindrical form, until they far exceed in dimensions the parent frustules, and at length, when mature, become, like these, transversely striated upon the surface. Thwaites terms these new individuals, *sporangia*, comparing them probably with the sporangia produced by conjugation in the Desmidieæ. In all these processes of conjugation there occurs at the same time an abundant secretion of a clear and gelatinous substance, which entirely envelopes the Diatomaceæ when in the act of conjugation, and thus retains them in connexion. I recognize, however, so far a difference between this mode of propagation and the conjugation of most of the Desmidieæ, that in the conjugation of the Diatomaceæ, neither a diminution nor increase in the number of individuals takes place; only *Fragilaria pectinalis* offers an exception to this: in the conjugation of which Thwaites saw only a single new and larger individual to be formed. It must at the same time here be noticed, that the new individuals produced in this remarkable way, not only exceed the parent individual in size, but also that they frequently exhibit a totally different form, so that there is no doubt but that in time many of the recognized Diatomaceæ will prove to be the so-termed sporangia of others. Thus Thwaites supposes that *Epithemia vertagus*, Kütz., is the sporangium of *Eunotia turgida*, Ehr.

From all the hitherto described unicellular Algæ, *Pediastrum* differs most essentially in its interesting mode of propagation. It is known that the plants described by Ehrenberg as *Micrasterias* constitute families, consisting of 4, 8, 16, 32, or 64 cells, which are disposed in the same plane, and united into discoid or stellate fronds. Ehrenberg, as usual, speaks of the polygastric apparatus, of the ovaries, and testes of these organisms; all of which organs appear to be brought *naturally* into harmony with those of the Infusoria. With respect to the propagation, Ehrenberg does not appear to have made any direct observations, for what he describes as spontaneous division of the single cells is, at any rate, incorrect. Two short remarks, made by Turpin and Meyen, on the propagation of *Pediastrum borganum*, are dismissed by Ehrenberg with equal brevity, although Meyen's notice is deserving of much consideration. What Turpin would appear to have seen, with respect to the dispersion of a mass of fine spores from the swollen extremities of the marginal cells of the same species of Pediastrum, and which he even figures ('Mem. du Muséum d'Hist. Nat.,' Vol. XVI., 1828, p. 320, Pl. XIII., fig. 22), is assuredly deceptive, because, as I am assured by A. Braun, the enlargements at the extremities of the Pediastrum in question are formed of thickened cellulose, and probably incapable of dehiscence. On the other hand, it appears from what Meyen says, that he had seen the remarkable propagation of the Pediastra. His words are as follows ('Nov. Act. Acad. Nat. Curios.,' Tom. XIV., Pars II., 1829, p. 774): "When old, the cells gradually burst, and the aggregated mass of spores escapes endowed with a motive faculty; the spores very soon come together, become loosely connected with one another, and, at the same time, lose the power of motion. The perfect individuals have no motion." That there is some truth in this statement I am satisfied from the close investigations which have been instituted by A. Braun on the subject of the propagation of the Pediastra. He was able to show me under the microscope, in *Pediastrum granulatum*, Kütz., that by segmentation of the cell-contents, 4, 8, 16, or 32 spores are developed in the interior of each cell of this Alga, which spores, after the dehiscence of the cells, escape from them enveloped in a delicate, colourless membrane, and after moving about confusedly, but actively, for some time, arrange themselves in one plane in a stellate manner, after which they gradually become quiescent and adhere to each other. The delicate external membrane with which these spores are at first surrounded gradually disappears, probably being dissolved. This motion and arrangement within the delicate tunic of *Pediastrum granulatum* agrees in all respects with the highly interesting phenomena observed by Braun in the second form of spores of the likewise unicellular Alga *Hydrodictyon utriculatum*. In this case also, the very numerous spores which are produced in each cell exhibit, if not active motions, yet a sort of quivering movement that lasts more than half an hour, until at last becoming applied to each other, they come to a state of rest, and being connected by means of the dilated mother-cell, arrange themselves into a new network, which becoming free by the solution of the mother-cell, acquires the original dimensions, and after about three weeks forms new spores.*

From this report on the more recent labours of botanists in the field of the lower *vegetable world*, it may be seen how important and indispensable the study of this branch of botanical knowledge must be for those who would successfully apply themselves to researches connected with the lower animal *kingdom.*

[The above paper by Von Siebold is not here given only for its intrinsic value, but because it has been thought that it would afford a pretty fair exposition of the views entertained at the time it was written by the more modern school of microscopical observers, and that it would serve as a starting-point from which to measure future progress in investigations of the nature of those to which it relates; and that so far it might be useful and desirable to give it a place in an early number of the Microscopical Journal. It is proper, however, to notice that there are several points in which it will be seen—chiefly, however, from subsequent observation—that the author has fallen into error.]

On the PSOROSPERMIA *and* GREGARINÆ. Müller's Archiv, 1851, pp. 221. By D. F. LEYDIG.

THE Psorospermia are microscopical corpuscles of a peculiar kind, which may be generally characterized, in the full-grown condition, as rounded organisms, having a sharply-defined outline, with or without a tail-like appendage. They are flattened and lenticular in figure, and one pole is usually acu-

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* For further and later information (1851) on the subject not only of Hydrodictyon, but generally on that of the formation, spores or gonidia in the lower Algæ, and for a most philosophical and comprehensive view of the whole matter, no better source can be consulted than A. Braun's (Betrachtungen üb. die Erscheinung der Verjüngung in der Natur. Leipzig, 1851, pp. 364), 'Considerations on the Phenomenon of Rejuvenescence in Nature,' a work of which it is impossible to speak too highly, and to which there will be frequent occasion of reference by all who are interested in the important subjects of which it treats. Nor can any one consider himself at all *au niveau* on the subject of the propagation and development of the lower Algæ who has not studied the elaborate paper by Cohn (Zur Naturgeschichte des *Protococcus pluvialis,* Kütz.), 'On the Natural History of *Protococcus pluvialis,*' contained in the 22nd vol. of the Nov. Act. Nat. Curios., 1850, which is a complete repertory of all known on the subject up to that period, and moreover exhibits many new points in a most clear and satisfactory manner. These valuable papers are of too great length for insertion in this Journal, but it is intended hereafter to give a sufficient abstract of each to place the facts and reasoning contained in them fairly before the English reader.

minate; and towards this pole several internal vesicles converge in a symmetrical manner. These creatures were discovered by Joh. Müller in 1841 (Müll. Arch., 1841, p. 477). He found in a young Pike minute round cysts in the cellular tissue of the muscles of the eye, in the substance of the sclerotica, and between this and the choroid coat. The contents of the cysts was a whitish substance, which, when examined microscopically, was found to consist of peculiar elements—the "Psorospermia." [A detailed notice of these observations is given in the 'Microscop. Journal,' vol. ii. p. 123, and in the 'Brit. and Foreign Med. Rev.,' January, 1842.] In the following year the same observer (Müller's Arch., 1842, p. 193) discovered parasitic corpuscles in the swimming bladder of a *Gadus callarius*, which, although specifically distinct from the Psorospermia, approached very near the latter in their organization. They resembled in general a smooth ventricose *Navicula*, and consisted of two elongated cases applied to each other at the cavity, and with an elliptical outline and convex outer surface. They were in part free, in part enclosed in masses within a tunic. Similar cysts, containing "Psorospermia," have been found by Leydig in several species of fish, and in all parts nearly of their bodies, and even in the blood contained in the heart (p. 223), and in the peritoneal cavity.

Some facts, however, observed by him, connected with this subject, which came under his notice in 1850, during some researches on the cartilaginous fishes, served to throw a more general light upon these mysterious forms.

In the gall-bladder of a *Squatina angelus*, there occurred, in the bile, and in large quantity, peculiar forms of various organization, but which were manifestly developmental forms. 1. Rounded vesicles, consisting of a delicate membrane and a consistent fluid. The latter was of a yellow colour and contained a multitude of also yellow granules. 2. Other vesicles presented, besides these, other elements of a new kind. In the middle of the granular contents were several perfectly transparent cellules. Small vesicles had only one of these cellules, larger ones as many as six. 3. Other parent vesicles, again, exhibited, besides their membrane, a granular contents and secondary vesicles, containing Psorospermia, always one in each secondary vesicle. 4. In the latter form, finally, the secondary vesicle had attained a large size, and the Psorosperm floated in a spacious clear chamber, which occupied nearly the whole of the parent cyst. Besides these motionless cysts, there were numerous free Psorospermia in the bile.

He found, upon examination, very similar things in other fishes of the same class,—as in *Spinax vulgaris*, *Scyllium* *canicula, Torpedo narke*, and *Raja batis*, in which the Psorospermia differed from the more usual form, in their being grooved or ribbed.

It was very remarkable that the above-described organisms were never met with in any other part or tissue of the body than the gall-bladder or biliary duct.

With respect to the nature of these bodies, Leydig is inclined to think that the cyst should be regarded as belonging to the family of the Gregarinæ, and that the "Psorospermia" must be looked upon as generically analogous to the "Pseudo-navicellæ," which have been observed to be generated within the Gregarinæ.

The question next arises as to the existence of similar Gregariniform organisms producing Psorospermia, in freshwater fishes. Leydig thinks there is reason to suppose that the animalcule discovered by Valentin in the blood of *Salmo fario* is a Gregarina. Moreover, John Müller and Leydig have observed two or three ecaudate Psorospermia in *Leuciscus dobulst*, enclosed in a cyst. Whence it might be supposed that secondary cells may be developed within one of Valentin's Hæmatozoa, after it has been conveyed, in the course of the circulation, to one organ or another; in which cells Psorospermia may originate. With the growth of the latter the granular contents of the Gregarinæ gradually disappear, which are thus transformed into cysts filled with Psorospermia. Such a cyst would then be equivalent to a Navicella-receptacle.

The author then proceeds to discuss the *vexata quæstio* of the true nature of the Gregarinæ; and, adverting to the conflicting views of Kölliker and Bruch, declares himself in favour of the latter, which assumes, as above stated, that the *Gregarina* is a transformed *Filaria*, or *Anguillula*.

In the intestine of a large species of *Terebella* he was enabled to observe the most distinct transition between Filaria-like nematoid worms and *Gregarinæ*. The forms of the latter which he observed, not once only but many times, were—1. A Gregarina of from 0·02‴ to 0·04‴ long, which had the form of an elongated sac, rounded at one extremity, and sharp at the other. The contents were those usual in the Gregarinæ, a consistent fluid with a corpuscular substance, which did not occupy the pointed end, and imbedded in this a clear vesicle with a nucleus. 2. A Gregariniform creature, of a spindle-shaped figure, closely resembling *Gregarina Terebellæ*, Köll 3. A Gregarina, generally resembling the preceding, differing only in two particulars. The internal substance is arranged in longitudinal streaks, and the body, instead of being straight, is more or less curved at each end. 4. The same form, but with the body more elongated, vermiform; and, for the first time, exhibiting motion. 5. A very pretty nematoid worm, about 0 10‴ long; blunt at one end, sharp at the other; the contents in longitudinal streaks, as in the two preceding forms, but with the spaces between them wider. Its motions are very active.

Leydig is induced, by considerations of the above facts, and by other reasons, to believe that the Gregarinæ are not perfect animals, but "a link in the series of development of the Helminthes," as Henle expresses it. Another question, however, arises: do the Gregarinæ become changed into Filaria-form worms, or is it that the Filaria-like worms are metamorphosed into Gregarinæ? Although at first inclined to consider the former as the true state of the case, Leydig is now disposed to follow Henle and Bruch, and adopt the latter view; otherwise it would seem impossible to account for the formation of the "Pseudo navicellæ" and "Psorospermia" within the Gregarinæ.

Experiments on the Transmission of INTESTINAL WORMS. By M. HERBST. Annales des Sciences Naturelles, tome xvii. No. 1, p. 63.

THE author's experiments appear to have been directed only to the *Trichina spiralis*, or allied species. He recognizes three species of this genus. The first, corresponding in all respects with that discovered in the human body by Hilton, Owen, and Bischoff, was met with in the voluntary muscles of a large old cat. Shortly afterwards he met with a second species in the mesentery of *Strix passerina.* It occurred in the substance of the muscles, and also in the mesentery, in which situation the worm occupied yellowish tubercles about the size of a pin's head. This *Trichina* is distinguished not only by a body double the size of that of the other, but principally by the abnormal form of its extremities. The enlarged head terminates in a short conical point, the surface of which is verrucose, and the attenuated tail seems to be furnished with two papillary protuberances at the extremity, as well as with an infundibuliform opening. The third species was met with by the author in 1848, in the muscles of a full-grown dog. The cysts were very small, scarcely visible to the naked eye. The vermiculi enclosed in them were much smaller, but in other respects resembled those of the first species, from which, consequently, it may be considered doubtful whether they are really specifically distinct.

In November, 1850, a female Badger, about two years old, that the author had kept partly on vegetables and partly on the remains of the animals which he had dissected, died. He discovered the presence of an infinite number of *Trichinæ* in all the voluntary muscles. This case seemed to afford a favourable occasion for new researches relative to the origin and formation of these worms.

In 1845 the author had failed in an experiment in the transmission of the *Trichinæ*. In that experiment he introduced thirty cysts containing living vermiculi between the skin and lumbar muscles of a young cat. At the end of a month the cysts were found fixed in their situations, but the vermiculi were dead. On the present occasion he proceeded differently. The flesh of the badger was given to some young dogs about six weeks old, and was devoured by them in the course of a few days. One of the puppies was sent into the country, and allowed to be at large, exposed to all the external atmospheric influences. On the examination of the other two, made on the 10th and 18th of February, 1851, all the voluntary muscles were found to be as abundantly infested with the *Trichinæ*, as were those of the badger which the puppies had devoured three months before. The length of the cysts was 133-1000th, their width 73-1000th, and the size of the vermicule 1166-100,000th of a line. It remained to ascertain the condition of the third dog, which was done after an interval of nine months, or in the beginning of November, 1851. The dog was adult, and in all respects vigorous and healthy in appearance.

On the 11th of November the author exposed the sterno-mastoid muscle, which, to the naked eye, exhibited nothing extraordinary; under the microscope, however, *Trichinæ* could be recognised in such vast numbers that in a portion of the muscle, weighing two or three grains, as many as six cysts could be detected; the length of these cysts was 33-1000th, their width 833-10,000th, the length of the worm 33-100th, and its diameter 1166-100,000th of a line. Now, as these worms are not common, and their appearance may be considered as a rare phenomenon, there can be no doubt that their presence in the three dogs in question was consequent upon their having eaten the flesh of the badger. The extreme tenacity of life in these parasites, which is not apparently affected by either heat or cold, must be considered as favourable to their propagation; but the great difficulty is with respect to the mode in which the ova of these worms, very minute and highly elastic, it is true, but which nevertheless present solid particles and determinate forms, reach the blood-vessels from the alimentary canal. For the abundant and simultaneous presence, as well as the uniform distribution of these *Trichinæ* in all the voluntary muscles, appear to justify the supposition that their ova are conveyed to the various spots in which the worms are lodged, in the course of the circulation of the blood. This question the author does not attempt to decide.

Contributions towards a Knowledge of the Lower Animals. By A. Kölliker. Abstracted from Siebold and Kölliker Zeitsch. Vol. I., p. 1.

This paper contains a description of various species of *Gregarina,* with detailed observations on their structure and position in the animal kingdom. The following is a summary of the conclusions at which the author arrives :—

1. The Gregarinæ are animals.

2. The simple Gregarinæ consist indubitably of a single cell ; their membrane corresponds to a cell-membrane, their contents to a cell-contents, the vesicle to a nucleus, the granule or granules within it to a simple or broken-up nucleolus.

3. The Gregarinæ which are constricted at the middle also correspond, most probably, with a single cell of a peculiar kind.

4. There is no reason whatever for supposing that the Gregarinæ are not perfect animals.

5. The cysts containing pseudo-Navicellæ arise, in the granular contents and vesicles, probably in a transformation of the Gregarinæ, that is, if they are to be looked upon as younger Gregarinæ.

6. This being supposed, then the pseudo-Navicellæ of the older cysts or receptacles are probably to be regarded as the germs of the Gregarinæ, which become either Gregarinæ themselves, or, what can hardly be considered probable, animals of another form, which, in the latter case, is to be regarded as the perfect form of the Gregarina.

7. The occurrence of two nuclei or two cells in the interior of certain Gregarinæ has either a relation to their multiplication, or is an introduction to their transformation into pseudo-Navicellæ-receptacles.

8. The connexion of certain Gregarinæ may depend upon a division of the pseudo-Navicellæ, on the supposition that these are the germs of Gregarinæ, or may originate in a sort

of longitudinal and transverse division of the youngest Gregarina.

Thirty-five species are enumerated: to which several have since been added by Leidy (Proceed. of the Acad. of Nat. Sciences of Philadelphia, vol. iv. p. 229, or Annals Nat. Hist., 2nd ser., vol. v. p. 317). Further observations also on the subject may be found by Stein in Müller's Archiv (August, 1849), or Annals Nat. Hist. (vol. v. p. 430); Henle (Jahresbericht über Histologie, 1845, p. 49); C. Bruch (Sieb. and Köll. Zeitsch., vol. ii. p. 110), who describes minutely the mode in which the pseudo-Navicellæ are formed, by a segmentation of the contents of a Gregarina, or of a process analogous to segmentation. He was unable to observe what further became of the Navicellæ, which, in the Earth-worm, upon the Gregarinæ inhabiting which Bruch's observations appear to have been principally made, certainly do not undergo any further change. He is inclined to think that the Gregarinæ are Filariæ in a quiescent state. He considers, therefore, that the Gregarinæ afford another instance of what has been termed "Alternation of Generations;" and upon the supposition that the Gregarina is an altered Filaria, it follows that the former cannot be regarded, properly, as a unicellular animal, seeing that the latter represents an entire vitellus, that is, an aggregation of cells. To these observations of Bruch, or, more properly speaking, of Henle, relative to the transformation of Filariæ into Gregarinæ, Kölliker (*op. c.*, p. 113) replies, that such an alternation of generations among the Nematoid Worms is elsewhere unknown, regarding, with Steenstrup and Siebold, that Miescher is incorrect in his observation of the transformation of the *Filaria piscium* into a globular membranous envelope, from which, at a subsequent period, a trematoid animal, and finally, a *Tetrarhynchus* proceeds. Although the change of a Filaria into a Gregarina is not an impossible circumstance, before we admit such a thing, it is first necessary to inquire whether the facts stated may not be otherwise explained. It is by no means proved that the Anguillula-like animal noticed by Henle, and termed by Bruch Filaria; the *Proteus tenax* of Dujardin (Ann. d. S. N., 2nd ser., tom. iv. p. 354); the *Sablier protéiforme* of Suriray (Ann. d. S N., 2nd ser., tom. vi. p. 356), is really a Nematoid Worm. Kölliker is more inclined to regard it as an Infusorium allied to *Opalina*, *Proteus*, &c. If this be the case, there is, according to him, nothing extraordinary in its transformation into a Gregarina, and finally into a Navicella-receptacle. He goes on to say (p. 114) that he maintains his original opinion that the Gregarinæ are perfect animals, which are of the nature of simple cells, and propagated, like many Infusoria, by germs, the so-called Navicellæ. He allows, however, that there are many points in their economy still requiring elucidation. [With reference to Kölliker's observation, that no instance of alternation of generations is as yet known among the Nematoid Worms, we may notice a paper by Mr. Busk in the 'Microscopical Transactions' for 1846, vol. ii. p. 65, Pl. X. on Filaria Medinensis, in which the author adduces facts and reasons which induce him to think it not improbable that an alternation of generations may take place in the case of that Entozoon.]

REVIEWS.

Die Pflanzenzelle, der innere Bau und das Leben der Gewächse, &c. (The Vegetable Cell, the Internal Structure, and Life of Plants, worked over in original comparative, microchemical researches). By Dr. Hermann Schacht. Berlin, 1852, roy. 8vo., 672 pp., and 20 plates with 390 figures, partly coloured.

This work, for which the author has recently received a decoration from the King of Prussia, was briefly alluded to in a former part, and we here take occasion to lay a somewhat extended account of it before our readers. Dr. Schacht's book is one that has attracted great notice, and will have considerable influence on the progress of the microscopic examination of vegetable structure, but this will not be so much the result of originality of the matter contained in it as of the method pursued in the investigations and in the exposition of them. In fact there are few new points, and the merits of the work rest chiefly upon the industry and directness with which the author has worked over the whole field of vegetable anatomy under the point of view laid down in his title, that of comparison of the tissues in the various classes, not merely by simple inspection, but by parallel series of observations on development, assisted by the systematic application of reagents for the determination of the chemical characters. The mode of operation pursued is thus described in the Introduction (p. 7).

> "In the first place, unless I had to do with simple cellular filaments, as, for instance, in *Confervæ*, I made the most perfect cross and long sections I could, and examined them in water, with a strong objective and a low ocular, ordinarily with *system* 9, and *ocular* 1 of my Oberhäuser microscope; then drew all my important preparations most accurately, and also frequently preserved the preparation in chloride of calcium for subsequent comparison, noting at the same time everything which could not be expressed in the drawing. Next, I treated equally perfect sections with solution of iodine, then with iodine and sulphuric acid; another equally good section was then treated with the chloride of zinc and iodine solution, others with concentrated sulphuric acid, and others again with sugar and sulphuric acid. After I had carefully observed the changes which each of these re-agents produced on the sections, had drawn and noted them, I boiled good cross and long sections in strong solution of potash, in a porcelain saucer, allowing the ley to boil up once or twice over the spirit-lamp; then taking out the preparation and laying it in water. Watch-glasses, which do very well for maceration, are unfit for boiling prepara-

tions, as the heat increases too quickly, and they split. The preparations, after being washed, were examined in water, then with the addition of each of the above re-agents."

The maceration by Schulze's process was applied to sections and to fragments of tissue. The re-agents were applied again to the preparations, and both in those boiled, and those macerated, the effects were often different from those on the simple sections. These operations were performed on cells of all kinds, and in a great variety of plants; moreover the same re-agents were applied in the same way to the young and the perfectly developed structures of the same plant. With this brief notice of the nature of the experimental observations we pass to a summary of the most important contents of the book as regards micrographical points.

The first section is devoted to a general *Introduction*, an account of the method of research and a description of the chemical elements of the tissues.

Sect. II. is devoted to the *Essential parts of the Vegetable Cell*, namely, the Cell-membrane, the Protoplasm, the Nucleus, the Primordial Utricle, and the Cell-sap with its contents.

In reference to the *Cell-membrane* we find no new point of importance; the author's observations are opposed to the speculations recently revived by Agardh, jun., that the *primary* membrane is composed of coherent fibres, and in this we are quite in agreement with him. His observations are opposed to Schleiden's idea, that the lenticular space between the contiguous "pits" of the Coniferæ arises from the formation of an air-bubble; he always found the space occupied by fluid. The details on the secondary deposits, the results of which confirm the views of Von Mohl in opposition to Harting and Mulder, will be found very instructive.—*Protoplasm* is always to be detected by the rose-colour it takes with sugar and sulphuric acid (the colour sometimes does not make its appearance for ten minutes).—*Nucleus.* The author believes that this body is never absent from young cells. In this view we are inclined to differ from him; indeed the invariable detection of nuclei in vegetable cells, by German physiologists, has always been a mystery to us, and which only seems explicable by supposing that every roundish granule or globular mass of plotoplasm is a nucleus or a nucleolus. Schacht does not venture to affirm the existence of a membrane of the nucleus *at any period.*—The *Primordial utricle* is stated, in agreement with Mohl, Henfrey, Mitscherlich, &c., to be constricted *gradually* in the increase of cells by division. *Cell-sap and Contents.*—Starch—the author agrees with Schleiden in his view, that starch grains are formed by successive deposit of layers around a nucleus. This is a very difficult subject, and one which is not nearly worked out yet. Chlorophyll-globules are stated to be without a membranous envelope, as supposed by Nägeli, Cohn, and Göppert. With regard to this, as also the similar membrane asserted by Nägeli to exist around starch, we often have seen what may easily be taken for such a structure, but cannot decide whether or not it is an optical deception.

Sect. III. treats of *the Origin of the Vegetable Cell*, which is described, in accordance with recent writers, as taking place in two ways, viz.: 1. *Free cell-formation* and 2. *Parietal cell-formation*, by division of the primordial utricle of the parent cell. He mentions under the latter head that the special parent-cells are not formed in the development of the pollen of *Œnothera*, or the spores of *Anthoceros lævis* (to which might have been added those of *Marchantia polymorpha*, and probably others). In Cambium-layers the cell-development is effected by the division of the primordial utricle of the parent-cell. The paragraph on the development of the leaf of *Sphagnum* is very interesting, and the more instructive from the ease with which the observations may be repeated.* A paragraph is also devoted to the history of development of the spores of the Truffle, which accords with our own observations.

Sect. IV. *The Growth and Nutrition of the Cell-membrane.* The author believes that the primary membrane enlarges by expansion, and becomes thinner thereby, but does not actually increase in substance by intussusception of molecules, as some have supposed. The walls are thickened by secondary deposits, always laminated, except in the case of spiral bands, in which no layers have yet been detected.

Sect. V. *The Cells of Vegetables as connected together.* Intercellular substance is believed to exist, but to a much smaller extent than is generally imagined; sometimes even not optically demonstrable. The real intercellular substance, as it occurs sparingly in collenchyma of rinds, &c., is coloured yellow by iodine. The bulky deposits at the angles of cells, often called intercellular substance, are, in almost all cases, as pointed out by Von Mohl, stratified deposits belonging to the cell-cavity, but rendered apparently exterior by changes occurring during growth. *Cuticle* is a subject on which a great deal has been written lately, not to a very decisive effect. Dr. Schacht adopts Von Mohl's distinction between *cuticle*, the thin layer, coloured yellow by iodine,

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* The curious structure of the cell wall in the leaf of Sphagnum renders that plant an interesting microscopic object.

found on the surface of plants, and the *cuticular layers* on the inside of the outer wall of the epidermal cells, which layers make up the greater part of the thickness of the hard epidermis. The external *cuticle* is regarded by our author as an excreted product, in which conclusion he rests greatly on the certainly strong case of the elegantly-marked cuticle of spores which, like those of the Truffle, originate free in the cavity of a parent-cell. This section is very important in the present stage of inquiry on this head, not, indeed, as striking out new light, but as a testimony to facts which as yet have not been repeated by many observers.

Sect VI., on the *kinds of Vegetable cell* and *Vegetable tissues*, is, perhaps, the most interesting in the work. The structures are divided into *free* cells, viz.:--1. The Swarming-filament cells (*Spermatozoid cells*) of the Cryptogamia; 2. the Spores of the Cryptogamia (under which are included the Swarming-spores—*zoospores*—of the Confervæ, more properly called *Gonidia*); and, 3. the Pollen grain;—and *Cellular tissues*, viz.: 1. Cells and tissues of Lichens and Fungi; 2. Cells and tissues of Algæ; 3. Parenchyma and its cells; 4. Cambium and its cells; 5. the Vessels of Plants; 6. Wood and its cells; 7. Liber-cells (containing much original observation); 8. the Epidermis; 9. the Stomates; 10. the Appendicular organs; and, 11. Cork. Our space does not allow our entering into the multitude of new and interesting facts ascertained by our author by the application of the micro-chemical method to these objects; but his pages will repay attentive study. It is, perhaps, scarcely worth while to advert to a curious error, for which the author has been much, and with a narrow-minded spirit, ridiculed by Walpers, viz., the statement that cotton is a liber-fibre It argues certainly a neglect of literature, but it does not follow because the author never saw cotton in its native capsules that he does not look well into the plants growing round about him. The author denies the old statements concerning milk-vessels, and, as in a separate paper published a year or two ago, declares that they are all simple or ramified liber-cells, analogous to those long known in the Apocynaceæ.

Sect. VII. The *Thickening Ring*, or Cambial Ring. In this section the author sets up a new doctrine, of much importance in vegetable anatomy, if correct, namely, that the cambium of the ring where a stem expands each year, is distinct from that of the vascular bundles, and that these may either coincide with the former or not, which has important bearings in respect to explication of the growth of many stems; but we are here again compelled to refer to the original.

Sect VIII. comprehends the *Vascular bundles.*

Sect. IX. *Stem*, *Leaf*, *Root*, *Bud*, and *Flower*. This section contains many speculative opinions, which it does not belong to our office to criticise here The same may be said of Sect. X on the *Growth of Plants*, and Sect XI., the *General Vital Phenomena of Plants*, except in regard to the paragraphs in the latter, on the movements of the protoplasm (circulation) in cells, which are very elaborate and instructive.

Sect. XII. The *Cell an Organ of Propagation*. This contains a good summary of the facts recently made out in this field, examined from an original point of view. In regard to the Phanerogamia, our author is a firm supporter of Schleiden's doctrine, that the embryo originates in the end of the pollen-tube. He obtained the prize of the Dutch Academy on this subject a few years back, and, although almost the only advocate besides Schleiden at the present time of this view, like that author he is exceedingly positive. We believe him to be wrong, from personal examination even of the cases on which he lays greatest stress, and, considering the circumstances, we are not inclined to think the matter one longer open to question; for we have had occasion to learn that Dr. Schacht met Dr. Hofmeister, one of the most earnest advocates of the other view, to compare preparations, and they parted *mutually unconvinced;* so that his preparations could not be quite so decisive as he asserts. It may be remarked that Mr. Smith's celebrated case of *Cœlobogyne* admits of a probable explanation, under the view that the embryonal vesicle originates in the embryo sac, but not under the hypothesis that it is formed in the end of the pollen-tube.

Sect. XII., and last, treats of the *Death of the Vegetable cell.* In an Appendix the author gives some account of the application of the polariscope to the microscope; but here he does not afford any new lights; in fact the use of that instrument is quite new to him. A more important contribution is a tabular view of the microscopic characters of the Coniferous woods.

In conclusion of our imperfect sketch of the chief contents of this work we cannot help expressing our admiration of Dr. Schacht's drawings, which are real drawings and not diagrams; moreover, the manner in which they are lithographed —printed in colours—is a triumph of the art. It is curious to compare this volume with some of the dingy "sugar-paper" products of the German press of a dozen years ago. All vegetable anatomists who read German ought to possess this work; and even simple microscopists will find it a mine of curious and interesting subjects for observation.

A. H.

Reports of Juries. Exhibition of Works of Industry of All Nations, 1851. Class X., Section Optical Instruments, Article Microscopes.

Although the Reports of the Juries of the Great Exhibition have had a wide circulation, we have determined, at the request of several of our subscribers, to make a few extracts from the Report on Microscopes, which, we think, will be interesting to the readers of our Journal. The introduction to this Report contains some interesting facts on the history of the construction of the microscope, but to these we have not now space to allude. The following remarks on the structure of the microscope are valuable :—

> "The powers varying from 1-inch to a quarter-inch focus, inclusive, are by far the most generally useful in the whole range of microscopic combinations, especially for educational purposes.
>
> "It must be remarked that it is advisable that the angle of aperture of the combinations should not be extended to its utmost possible limit, when destined for the general purposes of natural history or anatomical investigation.
>
> "Combinations of high power, and extremely extended angles of aperture, are excellent in developing one class of test objects, viz. minute lines or dots on plane surfaces, and admirably demonstrate the high perfection to which such glasses are capable of being carried by scientific opticians; but such combinations, with a less angle of aperture and more penetrating power, are far more generally useful and valuable to the minute anatomist and the naturalist.
>
> "In regard to the brass-work, we may observe that the qualities especially requisite in the stand of a microscope are simplicity of construction, portability, combined with sufficient weight to ensure safety and steadiness, with smoothness and accuracy of action in all the working parts, and such a construction as to distribute any tremor that may be communicated to the instrument equally over its body, stage, and other working parts. These desirable points are admirably attained in the form suggested by Mr. George Jackson, and adopted by Messrs. Smith and Beck, Ross, and other makers. For purposes of delineation, Nachet's (France, No. 1370) form of prism is more advisable than that of Wollaston's, as the former, having one reflection less than the latter, presents the image to the eye in an erect instead of an inverted position."

With regard to the form here said to have been suggested by Mr. George Jackson, we have the authority of that gentleman for stating that a microscope, in which the body was attached to a saddle travelling on a bent triangular bar, was originally made by Mr. Ross, and figured by him in the article 'Microscope,' in the 'Penny Cyclopædia.' Mr. Ross, it appears, afterwards abandoned this form, when Mr. Jackson again took it up, and, having obviated most of its defects, it has since been adopted by Messrs. Smith and Beck and other makers. The following remarks on the instruments exhibited at the Great Exhibition will be read with interest :—

"Ross.—A microscope, the mechanical parts of which are exceedingly good: the movements are very smooth and true; the stand is on a plan which is solid and steady, and at the same time not cumbrous. The object-glasses are constructed with different kinds of glass in the different compound lenses, forming a combination so as to double up the secondary spectrum, and this is done so well that scarcely any separation of colours can be detected. The angular apertures of the object-glasses examined are as follows:—

1-inch	focal length,	27°	aperture.
½-inch	,,	60°	,,
1-5th-inch	,,	113°	,,
1-8th-inch	,,	107°	,,
1-12th-inch	,,	135°	,,

"Both the half-inch and the one-eighth of an inch foci are purposely made of smaller proportionate aperture than the quarter-inch or the one-twelfth of an inch, as in all lenses of large aperture the image becomes indistinct from the slightest change of focus, and so, unless an object be an absolute plane, it is impossible to see the whole field tolerably distinct at once with an object-glass of large aperture. In the set examined, the inch, the half-inch, and the one-eighth of an inch, are intended for the general examination of objects; and the one-fourth and one-twelfth of an inch for the examination of minute structures.

"Smith and Beck.—A microscope, the stand of which in appearance is not highly finished, but their forbearance to expend time and money on elaborately finishing the non-working part has been adopted on the strong recommendation of some of the oldest naturalists in London, in order that students may acquire instruments with first-rate glasses at the least possible expense, and that such instruments may be brought within the compass of those whose means are limited. The stand is excellent in principle: the body, stage, and appliances beneath are all carried on one stout cast bar, on the recommendation of Mr. G. Jackson, by means of which the centering of the achromatic illumination is rendered easy and certain, and on any tremor being communicated to the instrument, it is equally distributed over the whole of the working parts.

"The lever motion to the stage of this instrument is the most easy and generally useful that has yet been applied. If used with the right hand, while the quick and slow adjustments to the focus are worked with the left, there are no animalculæ that cannot be readily followed, however fitful and rapid their movements; and any globule of blood pursuing its course through the most tortuous of the capillaries, can be steadily and easily traced, and every alteration of its form observed during its passage through these minute vessels. The field of view may also be swept horizontally or perpendicularly, and the most delicate micrometrical measurements made with great ease and precision. This stage is the invention of Mr. Alfred White; the rabbitted groove on which the body moves was suggested by Mr. G. Jackson, at whose recommendation the fulcrum of the stage movement was fixed to a spring, instead of to a rigid bar. The simplicity and efficiency of the whole of this stand is highly commendable. The object-glasses examined were of first-rate quality, and were as follows:—

2-3rd-inch	focus of	28°	aperture.
4-10th-inch	,,	70° to 75°	aperture.
4-10th-inch	,,	60°	aperture.
1-5th-inch	,,	100° to 105°	aperture.

"They are beautifully corrected for spherical aberration, but the secondary speculum has not been much diminished. The half-inch focus of 70° aperture is a wonderfully fine combination, easily showing objects, considered difficult for a one-eighth inch focal length a little more than a year since, and bearing the application of the higher eye-pieces in an unprecedented manner.

"There are two tables with revolving tops, by which the microscope can be turned readily round for the convenience of examination by different observers, and thus rendered a social instrument. The microscopes are furnished with portable silver reflector and annular condenser, which exhibit transparent objects upon a dark ground. (This invention was made by Mr. Wenham, and Smith and Beck claim its first execution.)

VARLEY AND SON.—A microscope, the stage of which is moved by parallel rods, with ball and socket joints, which gives an equable motion in all directions, and is specially adapted for the examination of living objects. A second microscope is exhibited, adapted for receiving vials in which aquatic plants or animalculæ may be kept in a living state for any length of time. The plant is secured to one side of the vial by a piece of cork, and thus is within the reach of the microscope. The vial is kept full of water, and is only corked when used, at which time it is held in a jacket to cut off all extraneous light; a dark chamber projects from it opposite to the magnifier, so that a single beam of light may be made to fall upon the part under examination. A third microscope, of a simple construction, is also exhibited, chiefly intended for beginners.

"KING.—A microscope stand, with micrometers and goniometers. It has a pyramidal tripod, with stage traversed in rectangular planes by micrometer screws. The parts of this instrument are so arranged that its weight is equally distributed over the base, and when inclined at its working angle, the principal weight is below the point of suspension, and the stand is steady and good. The traversing-stage is furnished with divided scales and verniers. The workmanship throughout this instrument is of the first order. It is furnished with many ingenious applications of subsidiary instruments, and of apparatus specially adapted to the examination of objects by polarized light, and goniometric apparatus for measuring the angles of microscopic crystals. The mode of illumination, by a prism worked into convex spherical surfaces, is also worthy of notice.

"PRITCHARD.—An old-fashioned achromatic microscope, with indifferent object-glasses. The working of the mechanical parts is very good. This form of instrument is that which led the way in the great advance that has been made in the microscope by the introduction of achromatic object-glasses.

LADD.—A microscope furnished with chain and spindle movements, in place of rack and pinion. This movement has been applied to the microscope many years since, by Mr. Julius Page. The motion is smooth, and totally free from loss of time, and is likely to stand well the effects of constant use.

"PILLISCHER.—A large microscope stand, which is good for its price, but unnecessarily large and inconvenient for use.

"JACKSON, E. AND W.—Plain and excavated slips of glass, sections of tubes of various forms, for the construction of cells for mounting wet preparations, and thin glass for covering them, of various thicknesses. These materials are exceedingly useful for scientific microscopists.

"HUDSON.—Microscopic objects intended for the use of the medical student, physiologist, and naturalist.

"HETT.—A variety of admirably-injected microscopic objects, illustrating the utility of the microscope to the physiologist.

"POULTON.—Some well-executed microscopic objects, with drawings to illustrate their structure.

"STARK.—Microscopic objects, mounted in *gutta percha* cells, instead of *glass*; and also slides for exhibiting opaque objects.

"SHARP.—A set of high power lenses, ten in number, for a microscope from one-tenth to one-hundredth of an inch focal length.

"SHADBOLT.—A sphero-annular condenser, for concentrating light on transparent objects while under microscopic examination, the object alone being illuminated whilst the field of view is dark.

"The principle of this condenser was suggested by Mr. J. F. Wenham, of Brixton, in his parabolic condenser. Mr. Shadbolt's condenser carries out Mr. Wenham's principle, with the advantage of superior reflecting arrangements, greater facilities of construction, and less liability of derangement.

"NATCHET (France).—The object-glasses, though inferior to both those of Ross, and Smith and Beck, are by far the best of the foreign ones. They vary from a focus of one inch to that of one eighteenth of an inch. The following were examined: that with—

1-18th of an inch focal length,	has an aperture of	134°
1-8th ,,	,,	108°
1-5th ,,	,,	88°

"In all of them the spherical aberration is not corrected; and although the method of adjusting by the separation of the lenses, invented by Ross, is adopted, yet the system is such that they are not correct at any distance. The workmanship of the stand is very good; and there are two ingenious forms of microscopes exhibited. One has the object-glass below the stage, with the tube inclined at a convenient angle and a reflecting prism for the examination of chemicals, or for dissecting transparent objects under fluids. The other is a dissecting microscope, with the body inclined in a convenient direction, and the image erected by reflecting prisms, so as to enable an observer to look in a convenient position whilst dissecting an object in fluid, which must be kept horizontal.

"Some microscopes excellent for their price were exhibited by Bernard (France). These instruments were the cheapest in the Exhibition, though none were of the first order.

"CHEVALIER (France).—A microscope, with indifferent object-glasses. The workmanship of the mechanical part, however, is very good, the mode of mounting is excellent, and the instrument is convenient for all kinds of microscopic observations."

Other instruments are referred to, but neither their excellence of workmanship nor optical power demand notice. Of preparations for the microscope, and microscopic drawings, there were many. Amongst the latter named in the Report, we may mention those of Mr. Leonard, who has largely contributed to the illustration of microscopic objects Of preparations, Mr. Topping exhibited an extensive series both of vegetable and animal structures.

"BOURGOGNE (France) exhibited a case of microscopic objects prepared in the usual manner. They are mounted in Canada balsam, and consist of sections of wood, and entomological and other preparations, with a selection of salts to illustrate the polarization of light.

"NOBERT (Prussia), of Barth, has exhibited his wonderful tracings on glass. The plan adopted by him is to trace on glass ten separate bands at equal distance from each other, each band being composed of parallel lines of some fraction of a Prussian inch apart: in some they are 1-1000th, and in others only 1-4000th of a Prussian inch separated.

"The distance of these parallel lines form parts of a geometric series; thus—

0·001000 line.
0·000857 „
0·000735 „
0·000630 „
0·000540 „
0·000463 „
0·000397 „
0·000340 „
0·000292 „
0·000225 „

"To see these lines at all it is necessary to use a microscope with a magnifying power of 100 diameters; the bands containing the fewest number of lines will then be visible. To distinguish the finer lines it will be necessary to use magnifying power of 1000, and then the lines which are only 1-47000th of an inch apart will be seen as perfectly traced as the coarser lines. Of all the tests yet found for object-glasses of high power these would seem to be the most valuable. These tracings have tended to confirm the undulating theory of light, the different colours of the spectrum being exhibited in the ruled spaces according to the separation of the lines; and in those cases where the distances between the lines are smaller than the lengths of the violet light waves, no colour is perceived; and it is stated that if inequalities amounting to ·000002 line occur in some of the systems, stripes of another colour would appear in them."

AN INTRODUCTION TO CLINICAL MEDICINE. By JOHN HUGHES BENNETT, M.D. Second edition. Edinburgh. Sutherland and Knox.

To those commencing the study of the medical profession this little book will be found very valuable. Few of the manuals that have been published with the same object in view are so much up to the time as this little work by Dr. Bennett. We are induced to give it a notice in our pages, as out of the six lectures of which it consists two are devoted to the Microscope as a means of diagnosis. Nor do we think the space thus occupied disproportionate to the just value of this instrument in the hands of the medical practitioner. A successful treatment of disease, let *practical* men say what they will, can only be insured by an accurate knowledge of disease; and there can be no accurate knowledge of diseased tissues or morbid actions but by the aid of the microscope. It must not, however, be supposed that the microscope is an instrument easily used; that all a man has to do in order to profit by its revelations is to purchase an expensive apparatus at one of our great opticians. As with the eye itself, the practice of observation with the microscope demands a careful education. Only by instruction under a careful teacher or a systematic course of private observation can any one expect to use this instrument with success. Whether for public courses or private study, Dr. Bennett's book will supply a good outline of the objects that ought to be examined by a medical man. The principal physical characters to be regarded in microscopic examinations are described in the following passages :—

"1. *Shape.*—Accurate observation of the shape of bodies is very necessary, as many of these are distinguished by this physical property. Thus the human blood globules, presenting a biconcave round disk, are in this respect different from the oval corpuscles of the camelidæ, of birds, reptiles, and fishes. The distinction between round and globular is very necessary to be attended to. Human blood corpuscles are round and flat, but they become globular on the addition of water. Minute structures seen under the microscope may also be likened to the shape of well-known objects, such as that of a pear, balloon, kidney, heart, etc. etc.

"2. *Colour.*—The colour of structures varies greatly, and often differs, under the microscope, from what was previously conceived regarding them. Thus the coloured corpuscles of the blood, though commonly called red, are, in point of fact, yellow. Many objects present different colours, according to the mode of illumination ; that is, as the light is reflected from or transmitted through their substance, as in the case of certain scales of insects, feathers of birds, etc. Colour is often produced, modified, or lost, by re-agents, as when iodine comes in contact with starch corpuscles, when nitric acid is added to the granules of chlorophyle, or chlorine water affects the pigment cells of the choroid, and so on.

"3. *Edge or Border.*—The edge or border may present peculiarities which are worthy of notice. Thus it may be dark and abrupt on the field of the microscope, or so fine as to be scarcely visible. It may be smooth, irregular, serrated, beaded, etc. etc.

"4. *Size.*—The size of the minute bodies, fibres, or tubes which are found in the various textures of animals can only be determined with exactitude by actual measurement in the manner formerly described. It will be observed, for the most part, that these minute structures vary in diameter, so that when their medium size cannot be determined, the variations in size from the smaller to the larger should be stated Human blood-globules in a state of health have a pretty general medium size ; and these may consequently be taken as a standard with advantage, and bodies may be described as being two, three, or more times larger than this structure.

"5. *Transparency.*—This physical property varies greatly in the ultimate elements of numerous textures. Some corpuscles are quite diaphanous, others are more or less opaque. The opacity may depend upon corrugation or irregularities on the external surface, or upon contents of different kinds. Some bodies are so opaque as to prevent the transmission of the rays of light, when they look black by transmitted light, although they be white, seen by reflected light. Others, such as fatty particles and oil globules, refract the rays of light strongly, and present a peculiar luminous appearance.

"6. *Surface.*—Many textures, especially laminated ones, present a different structure on the surface from that which exists below. If, then, in the demonstration these have not been separated, the focal point must be changed by means of the fine adjustment. In this way the capillaries in the web of the frog's foot may be seen to be covered with an epidermic layer, and the cuticle of certain minute fungi or infusoria to possess peculiar markings. Not unfrequently the fracture of such structures enables us, on examining the broken edge, to distinguish the difference in structure between the surface and the deeper layers of the tissue under examination.

"7. *Contents.*—The contents of those structures, which consist of envelopes, as cells, or of various kinds of tubes, are very important. These may consist of included cells or nuclei, granules of different kinds, pigment matter, or crystals. Occasionally their contents present definite moving currents, as in the cells of some vegetables, or trembling rotatory molecular movements, as in the ordinary globules of saliva in the mouth.

"8. *Effects of Re-agents.*—These are most important in determining the structure and chemical composition of numerous tissues. Indeed, in the same manner that the anatomist with his knife separates the various layers of a texture he is examining, so the histologist, by the use of re-agents, determines the exact nature and composition of the minute bodies that fall under his inspection. Thus water generally causes cell formations to swell out from endosmosis; whilst syrup, gum-water, and concentrated saline solutions cause them to collapse from exosmosis. Acetic acid possesses the valuable property of dissolving coagulated albumen, and, in consequence, renders the whole class of albuminous tissues more transparent. Thus it operates on cell walls, causing them either to dissolve or become so thin as to display their contents more clearly. Ether, on the other hand, and the alkalies, operate on the fatty compounds, causing their solution and disappearance. The mineral acids dissolve most of the mineral constituents that are met with, so that in this way we are enabled to tell with tolerable certainty, at all events, the group of chemical compounds to which any particular structure may be referred."

Short accounts are given in the book of the appearances of the saliva, milk, blood, pus, sputum, vomited matters, fæces, uterine and vaginal discharges, mucus, dropsical fluids, urine, and cutaneous eruptions and ulcers. In a manual of 130 pages, of course no detail could be expected on these subjects. What is given bears the stamp of being the result of the author's own investigations on the subjects he treats, and will be found all the more valuable as coming from one who is a good physiologist as well as a diligent practical physician.

A SYNOPSIS OF THE BRITISH DIATOMACEÆ. By the Rev. WILLIAM SMITH. The Plates by TUFFEN WEST. Vol. I. London: Van Voorst.

AMONGST the organic beings whose existence the microscope has demonstrated, few possess a higher interest than the group now known as the family of Diatomaceæ. Appearing everywhere as the first-born of Life, wherever inorganic matters are fit for its development, these beings were looked upon suspiciously by early observers, and, whilst regarded by some as doubtful in nature, were looked upon by others as evidences of spontaneous generation. Their siliceous structure, which was early known, served to give them a strange resemblance to the mineral world, whilst, although endowed with motion, they presented no traces of organic tissues. The labours, however, of Ehrenberg set at rest the question of their belonging to the mineral world, and showed how great their claims were to be regarded as members of the animal kingdom. Their relationship to the Desmideæ was always apparent, and these beings were placed by Ehrenberg also in the animal world. But as evidence of the vegetable nature of the Desmideæ multiplied, so it became evident that the Diatomaceæ must follow. The fact that both these families produce sporangia as the result of conjugation in common with a large number of the confervæ, give them a common character which could hardly be assigned to beings belonging to both the animal and vegetable kingdoms. Hence Diatomaceæ are now commonly regarded as plants. But whilst zoologists have readily admitted this argument, the botanist on other grounds has rejected the Diatomaceæ from his domain. Schleiden, in his 'Principles of Botany,' refuses, on the ground of the complicated and unplantlike structure of Diatomaceæ, to recognise them in the vegetable kingdom. Organisms which have thus constituted the battle-field of systematists must have more than usual interest for those who employ the instrument by which alone they can be discerned. But independent of this, there is scarcely any class of objects that present more beautiful forms, and none that invites the microscopist to a higher trial of the greatest powers of his instrument. On these accounts the present work could hardly fail to be popular from the subject on which it treats, and when to this is added the well-known reputation of the author for researches upon the Diatomaceæ, we need hardly say that the work needs no recommendation from ourselves.

The present volume is illustrated with a frontispiece and thirty-one plates, all of which have been drawn from nature and engraved by Mr. Tuffen West. As this gentleman has executed all the plates for the Microscopical Journal, our readers have at once the opportunity of forming an opinion of the merits of the illustrations to Mr. Smith's work. We have no hesitation in pronouncing them to be superior to anything we know that has been published on the subject. By far the larger proportion of the illustrations are devoted to new species which have now been published for the first time. We may perhaps be allowed to doubt the permanence of many of these forms, although we do not the propriety of recording them. There is at present so great a shaking amongst the dry bones of species which systematists have recorded that we cannot but feel that some of Mr. Smith's forms may turn out transitionary. Not more than half the species are gone through in the present volume. It includes the well-known genera *Cocconeis*, *Campylodiscus*, *Surirella*, *Nitzschia*, *Navicula*, *Stauroneis*, *Pleurosigma*, *Synedra*, *Cocconema*, and

Gomphonema and others, whilst the larger and even more typical genera of *Bacillaria*, *Meridion*, *Diatoma*, and their allies, are yet to come.

The work, in addition to the description of the species, with drawings of each, contains a general Introduction, in which the habitats, structure, functions, and the modes of collecting and preserving specimens are entered into. From the section on habitats we select the following extract:—

> They inhabit the sea or fresh water, but the species peculiar to the one are never found in a living state in the other locality, though there are some which prefer a medium of a mixed nature, and are only to be met with in water more or less brackish. The latter are often found in great abundance and variety in districts occasionally subject to marine influences, such as marshes in the neighbourhood of the sea, or the deltas of rivers, where, on the occurrence of high tides, the freshness of the water is affected by percolation from the adjoining stream, or more directly by the occasional overflow of its banks. Other favourite habitats of the Diatomaceæ are stones of mountain streams or waterfalls, and the shallow pools left by the retiring tide at the mouths of our larger rivers. They are not, however, confined to the localities I have mentioned,—they are, in fact, almost ubiquitous, and there is hardly a roadside ditch, water-trough, or cistern, which will not reward a search, and furnish specimens of the tribe.
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> The indestructible nature of their epiderm has also served to perpetuate the presence of these forms in numerous localities, from which their living representatives have long since disappeared. Districts recovered from the sea, in the present or other periods of the earth's history, frequently contain myriads of such exuviæ forming strata of considerable thickness. Such deposits have been found in Bohemia, in the neighbourhood of Berlin, in various districts in Italy, and in several of the American States. The city of Richmond in Virginia is said to be built upon a stratum of Diatomaceous remains 18 feet in thickness, and extensive tracts in the Arctic Regions have been found covered with similar relics of a former vegetation.
>
> Nor are we without examples, though on a less extensive scale, in our own country. The ancient site of a mountain lake in the neighbourhood of Dolgelly, localities of a somewhat similar kind near Lough Island-Reavey, in Down, and Lough Mourne, in Antrim, have furnished large supplies of some of the forms described in the present work. Several deposits of a like kind have been met with in Scotland, and have also contributed to enrich the present volumes. The extreme minuteness of the organisms which have furnished such remains, and the hardness of their material, have rendered the substance formed by their aggregation, a useful agent in the mechanical arts, in which it has been employed to confer a polish upon hard surfaces. It is from this circumstance that the material known as Tripoli derives its value as a polisher of metals; and the Dolgelly deposit has to some extent been employed for a similar purpose.
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> One of the most singular instances of the preservation of Diatomaceous forms occurs in regard to Guano, so largely imported as a manure from Peru and Africa.

Mr. Smith regards the siliceous skeleton, as it has been called, as perfectly homologous with the epidermal tissues of many vegetable organs, and the botanist will immediately recall to mind such instances as *Deutzia scabra*, *Equisetum*, and many of the palms and grasses in which silex enters into the epidermal tissues. It is true in these higher plants we have nothing so perfectly regular as the siliceous plates of Diatomaceæ present, but it seems to be a law both in the vegetable and animal kingdoms, that the lower we descend in the scale of organization the more tendency do the inorganic constituents exhibit to submit to the inorganic law of crystallisation or symmetry of form. The following is a brief summary of Mr. Smith's view of the nature of the siliceous part of these structures:—

> The epiderm of the Diatom consists of two siliceous plates or valves, usually of the most perfect symmetry. When first produced, these valves are closely applied to each other, and the line of junction forms a suture along which the valves readily separate during the process of self-division which speedily follows the perfect formation of the cell. It seems to be a law with these organisms, that no portion of the internal cell-membrane can be exposed to the free action of the surrounding water, without secreting a siliceous epiderm; the moment the valves become separated in the process of self-division, we consequently find that the secretion of a third plate of silex commences. This plate forms a band between the valves, and will for convenience sake be afterwards spoken of as the Connecting Membrane. As self-division is continually going on while the frustules are in a healthy or growing state, it is rare to find a specimen in which the valves are not in some degree separated, and consequently in which there is not more or less of a connecting membrane.

Mr. Smith describes "a distinct movement of the granular particles of the endochrome closely resembling the cell-contents in *Closterium Lunula*."

> This circulation has not, however, the regularity of movement so conspicuous in the Desmidieæ, and is of too ambiguous a character to furnish data for any very certain conclusions, save one, viz. that the Diatom must be a single cell, and cannot contain a number of separate organs, such as have been alleged to occupy its interior; since the endochrome moves freely from one portion of the frustule to another, approaching and receding from the central nucleus unimpeded by any intervening obstacle.

On the movements of the entire frustule Mr. Smith has no satisfactory theory to offer. He has never been able to discover any semblance of a motile organ. He suggests that the movements may depend on endosmotic and exosmotic action. We must pass over the sections on self-division and classification, and give a concluding extract from the directions for collecting and preserving the Diatomaceæ:—

> Let him provide himself in the first place with the necessary apparatus. For the field, this includes a good stock of small wide-mouthed bottles, that each gathering may be kept perfectly distinct; a long rod or stick, to which can be attached a small muslin net; a cutting hook, of about three inches in length; and a broad flat spoon: the first, to collect such specimens as float upon the surface, or are held in suspension by the water; the second, to remove the larger Algæ which may be covered with parasitic

Diatoms; and the third, to skim the surface of the mud for those which lie at the bottom of the pool.

He will probably find, notwithstanding every care, that his specimens are mixed with much foreign matter, in the form of minute particles of mud or sand, which impair their value, and interfere with observation, especially with the higher powers of his instrument. These substances the student may remove in various ways; by repeated washings in pure water, and at the same time, profiting by the various specific gravities of the Diatoms and the intermixed substances, to secure their separation; but more particularly, by availing himself of the tendency which the Diatomaceæ, in common with all growing plants, possess, of making their way towards the light. The free forms may be thus procured in a tolerably clean state; all that is necessary being, to place the gathering which contains them in a shallow vessel, and leave them undisturbed for a sufficient length of time in the sunlight, and then carefully to remove them from the surface of the mud or water.

Having performed these operations, which a little practice will render comparatively easy and generally successful, the next proceeding is to preserve the specimens in such a manner as to render them suitable for examination by the microscope at any future time. This may be done in various ways, according to the nature of the species and the precise object desired.

The simplest method, and the one most generally useful to the scientific observer, is simply to dry the specimens upon small portions of talc, which can at any time be placed under the microscope, and examined without further preparation; and this mode possesses one great advantage, that the specimens can be submitted without further preparation to a heat sufficient to remove all the cell-contents and softer parts, leaving the siliceous epiderm in a transparent state.

We trust Mr. Smith will not keep us waiting long for his second volume, and we feel that we have said enough to show that no one can for the future study the Diatomaceæ without having recourse to this work, which will, we are assured, become a standard one on the subject.

A HISTORY OF INFUSORIAL ANIMALCULES LIVING AND FOSSIL. Third Edition. By ANDREW PRITCHARD, M.R.I. London: Whittaker & Co.

THIS work contains the largest amount of information on the subject of animalcules to be found in the English language. Its foundation seems to be the ‘Infusionsthierchen’ of Professor Ehrenberg, and his classification has been adopted in the systematic part of the work. The author has added a large quantity of matter from other sources, more especially from the writings of English naturalists on the subject. It is illustrated with twenty-four plates, embracing figures of a very large proportion of the Infusoria after Ehrenberg, Ralfs, Gosse, Smith, and others. With all the attention and expense that have evidently been bestowed on this book one is provoked to find it so carelessly got up. The introductory history contains a great quantity of very useful information, but it is not well arranged. Every one, however, who is employed in investigating the forms of animalcules will find here a repertory of matter to assist him in his labours. We are annoyed again at the perpetual misprints which, in a costly book with pretensions like this, are quite inexcusable. Who would expect to find our friend Mr. Bowerbank under the cacophonious spelling of "Brawerbank"? Mr. Brown's remarks on molecular movements are spoken of as the mo*ll*ecular motions of Dr. R. Brown*e*. An order Diamomaceæ is recognised, and Linchens is a substitute for Lichens. Cursorily glancing through the pages we have the following instances of mispelling:—"Monas crepuseulum," "an Algæ," "Eyistylis," "Ampileptus," "Infusionthierchen," "Infusionsthierschen," and we might add many more. We make these remarks in no mere critical spirit, but with a desire that a work which is, without doubt, the most important one on the subject in our language, should, if it reaches another edition, be rendered free from these eye-sores, which must be annoying to every educated reader.

NOTES AND CORRESPONDENCE.

As many of your metropolitan readers may be glad to know of localities in which microscopical objects may easily be found, I beg leave to state for their information that the waters of the New River, the ornamental water in St. James's Park, and the fountains in Trafalgar Square, will prove well worthy of investigation.

During the last two months I have obtained from the New River, near the City Road, *Cocconeis clypeus*, *Cocconeis pediculus*, *Fragillaria pectinalis*, *Synedra valens* and *lunaris*, *Closterium Leiblinii*, *Odontidium mesodon*, *Navicula Hippocampus* and *amphirynchus*, *Hydatina senta*, *Surirella striatula*, an arborescent *Vorticella* with 38 animalcules, *Tardigrada*, *Gomphonema truncatum*, and a *Vibrio*, the species of which, from unfortunately losing the specimen, I could not determine.

From Trafalgar Square, abundance of common *Naviculæ*, the *Dytiscus*, *Lurco*, *Vorticella Convallaria* and *Campanula* in great profusion, especially on a beautiful specimen of *Cladophora glomerata*.

From the Regent's Park, *Amœba* (? *diffluens*), *Aneurea testudo*, *Gomphonema truncatum* and *minutissimum*, *Bacillaria*, *Vorticella Convallaria*, *Paramecium Chrysalis*, and the commoner Naviculæ in incredible profusion. Hitherto I have only tried the water at the southern side, near the ferry.

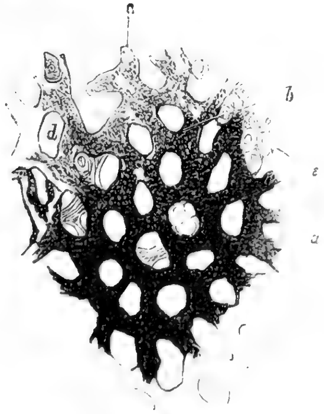
I may also mention that the small pools in fields at the back of the Norwood Cemetery were very rich last October in *Volvox globator* and the variety *aureus*, and in Green Hydras. —J. M. R., *Islington*.

On the Capillaries of the Liver.—In the last part of Todd and Bowman's Physiological Anatomy a doubt is expressed concerning the nature of the ultimate passages through which the blood circulates in the liver. Whether the smallest blood-vessels of this organ are true capillaries, that is, are possessed of a single tunic like other vessels of this description, or whether the blood passes along mere spaces, or channels formed by the hepatic corpuscles, so as to be in actual contact with their cell-walls, is regarded by these authors as a question yet to be decided.

Having at this time in my possession a portion of injected human liver, in which I have no difficulty in showing the smallest capillaries, and in demonstrating their tunic, the following observations will, I hope, be considered worthy of a place in your valuable Journal: first, because any doubt proceeding from such high authorities cannot fail to unsettle a point of minute anatomy which the microscope has satisfactorily established, and thereby to weaken general confidence in the results of all other microscopical observations; and secondly, because the supposed fact of mere blood-channels existing in the liver whilst true capillaries are demonstrable in other glands seems to depart too widely from a general law to have even the sanction of probability in its favour.

The examination necessary to show the capillaries of the liver is best made on a very thin slice of injected liver taken from a part bordering on that where the injection begins to fail, so that in the same slice there may be one part fully injected, but of course without any extravasation, another in which the vessels contain but little of the colouring matter of the injection, and a third, immediately continuous with this, in which the capillaries are empty. But, before examining this section, it must have been submitted to a gentle current of water trickling over it, in order that the biliary corpuscles may be entirely washed away from the meshes of those capillaries which project from the thinnest part of it; so that these vessels, being free in the field of view, may be seen by transmitted light, as a transparent object.

Such is the section from which the accompanying drawing was taken by my friend Dr. Bristowe.



Portion of the Liver as seen by 1-8*th of an inch lens.*

a Capillaries filled with injection.
b Ditto imperfectly injected.
c Ditto containing no injection.
d Meshes from which the hepatic corpuscles have been entirely removed.
e Ditto with corpuscles in them.

In respect to their structure these capillaries differ but little from those of other parts; their calibre in the liver I have always observed to be very unequal, arising most probably from the manner in which they are compressed by the corpuscles which lie in immediate contact with their walls, and fill up the areolæ produced by their numberless inosculations. Their average diameter is about 1-3000th of an inch. Their tunic is remarkably thin and transparent, and, so far as I have seen, without nuclei; but in this respect these vessels are not unlike the capillaries in many other parts. The meshes are generally circular or oval, and about 1-1000th of an inch in diameter, although some are larger and others smaller.

The difficulty of displaying the capillaries of the liver I believe to arise from the close connexion of the hepatic corpuscles with their walls (there being in this organ no visible basement membrane), and the extreme fragility of the latter; so that the means employed to remove the corpuscles from the meshes of the capillaries will break away the vessels also. This, I think, will not be so likely to take place if the part have been kept a few days before examined, and be treated in the manner above described.

I may observe that Mr. Busk has examined portions of this liver with me, and has allowed me to state that he entertains no doubt whatever of the existence of a wall in the capillaries of the liver as in other glands.—GEORGE RAINEY, M.R.C.S., *Demonstrator of Anatomy and Microscopic Anatomy, St. Thomas's Hospital.*

On a peculiarity in the thickening Layers of Vegetable Cells.—In the 'Botanische Zeitung' of September 27, 1850, Dr. H. Schacht described a peculiar appearance he had observed in the secondary deposits of the wood-cells of *Caryota urens*, *Hernandia sonora*, *Phœnix dactylifera*, and *Cocos botryophora*, consisting of slits in certain of the secondary layers, often taking a more or less spiral direction around the cell-wall. These cracks, as they may be termed, were often covered up again by subsequent deposits in the inside, so that they become narrow canals, running in the thickness of the wall formed by secondary layers. In examining some cells of *Hydrodictyon utriculatum* recently, we observed phenomena of the same kind; and as it appears likely that something of the same kind has given rise to J. G. Agardh's* idea of the cell-membrane generally being composed of fibres, we have thought it worth while to direct attention to these points. These slit-like marks are well seen in portions of the cells of *Hydrodictyon*, which have been kept in chloride of

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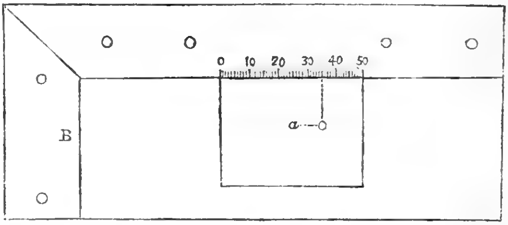
* De cellulâ vegetabili fibrillis tenuissimis contextâ. Lund., 1852.

calcium, and the spiral direction of them is very evident towards the extremities of the cells. It is probable that a similar structure will be found, on more careful examination, on the walls of many of the Conferveæ, which become much thickened.—Arthur Henfrey, March, 1853.

The Finder.—Take a flat bit of wood, box, or ebony, or it may be ivory, half an inch longer and broader than your slides, and about the eighth of an inch thick.

Along the top of this cement a bit of ivory, half an inch wide and as thick as the general run of your slides, and cement a similar bit of ivory on the left-hand end of it.

Now, it is obvious that your slide will *exactly* fit upon that portion of the bit of wood upon which the slips of ivory are *not* fixed. Next, in that part of the wood which is under the *middle* of the slide, cut a hole an inch long adjoining the slip of ivory, and three-quarters of an inch broad; then graduate that part of the ivory which adjoins the hole to fiftieths of an inch, and thin the ivory bevel from behind adjoining the hole, to make the graduations *transparently* visible.



To make use of the finder, place your slide in it with the left end of the slide close up to the shoulder at B.; then happening to observe an object—suppose a fossil *Navicula*, for instance, at *a*, which you wish to find again, bring it into the centre of your field; then, with the vertical motion of your stage, move the slide down till the graduated scale comes into your field. Now, observe the number on the scale that is in the centre of the field, and mark this number on your slide "Navicula! 35."

When next you want to find *this Navicula*, put the slide as before into the finder, bring the scale into your field, and 35 on the scale into the *centre* of your field; then, by the vertical motion of your stage *gradually* raise your slide till the object which you are seeking comes into view.—John Tyrrell, *County Court Judge of Devon, New Court.*

On the History of the Vinegar Plant.—Much was said and written on this plant about a year back, and we made a long series of observations on it, confirmatory of the opinion of Mr. Berkeley, that it is the mycelium of *Penicillium glaucum*, but there are many interesting points in its history which we cannot yet clear up. A curious fact has recently occurred to us. A piece of the gelatinous mass was dried and kept for some months, and then placed in a solution of refined sugar. After remaining in a dark closet about three months, through the winter, the solution is found still sweet, no trace of acid reaction being given with litmus paper. The fructification of the fungus is abundant, but the mass of mycelium is *blood-red*, looking, in fact, like a mixture of half coagulated blood and water. This brought to mind an observation made some years ago, of red spots among mould upon decaying paste, which were found to depend on innumerable minute oval cells, with two granules (so-called nucleoli) in each. These exactly resemble detached cells of the mycelium (gonidia?), often occurring abundantly in the jelly of the Vinegar plant; and, moreover, they are, in all probability, the same bodies described and figured by G. Fresenius* as a new species of fungus, occurring on starch jelly, under the name of *Cryptococcus glutinis.* These structures are evidently related to the "blood on bread" Fungus described by Ehrenberg, Montagne, and others.—ARTHUR HENFREY, March, 1853.

Mode of isolating Naviculæ and other Test Objects.—Having found the methods ordinarily employed very tedious, and frequently destructive of the specimens, I adopted the following plan:—Select a fine hair which has been split at its free extremity into from 3 to 5 or 6 parts; and having fixed it in a common needle-holder by passing it through a slit in a piece of cork, use it as a forceps under a 2-3rds of an inch objective, with an erecting eyepiece. When the split extremity of the hair touches the glass slide, its parts separate from each other to an amount proportionate to the pressure, and on being brought up to the object are easily made to seize it, when it can be transferred as a single specimen to another slide without injury. The object is most easily seized when pushed to the edge of the fluid on the slide.

Hairs split at the extremity may always be found in a shaving-brush which has been in use for some time. Those should be selected which have thin split portions so closely in contact that they appear single until touched at their ends.

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* Beiträge zur Mykologie, von G. Fresenius. Heft II. Frankfort on the Maine, 1852.

I have also found entire hairs very useful when set in needle-holders in a similar manner, any amount of flexibility being given to them by regulating the length of the part of the hair in use.—P. REDFERN, *Aberdeen.*

Notice of a Binocular Microscope.—I devised last year, and have lately constructed and used, a combination of glass prisms, to render both eyes simultaneously serviceable in microscopic observation

Behind the objective, and as near thereto as practicable, the light is equally divided and bent at right angles, and made to travel in opposite directions, by means of two rectangular prisms, which are in contact by their edges somewhat ground away. The reflected rays are received at a proper distance for binocular vision, upon two other rectangular prisms, and again bent at right angles; being thus either completely inverted for an inverted microscope; or restored to their first direction for the direct microscope. These outer prisms may be cemented to the inner by Canada balsam; or left free to admit of adjustment to suit different observers. Prisms of other form, with due arrangement, may be substituted.

I find the method is applicable, with equal advantage, to every grade of good lens, from Spencer's best sixteenth to a common three-inch magnifier; with or without oculars or erecting eye-pieces; and with a great enhancement of penetrating and defining power. It gives the observer perfectly correct views, in length, breadth, and *depth*, whatever power he may employ. Objects are seen holding their true relative positions and wearing their real shapes. A curious exception must be made. In viewing opaque solid bodies, with one eye-piece to each eye, depression appears as elevation, and elevation as depression, forming a singular illusion. For instance, a metal spherule appears as a glass ball silvered on the under side; and a crystal of galena like an empty box. By the additional use of erecting eye-pieces the images all become normal and natural. Match drawings of any solid object, made from each eye-piece, by the aid of the camera lucida, when properly placed in the common stereoscope, appear to stand out in natural relief. These, if engraved and printed in the proper position with respect to each other, might find an appropriate place in books on the arts and sciences.

In constructing binocular eye-glasses, I use, for lightness and economy, four pieces of common looking-glass, instead of prisms.

With these instruments the microscopic dissecting knife can be exactly guided. The watch-maker and artist can work under the binocular eye-glass with certainty and satisfaction. In looking at microscopic animal tissues, the single eye may, perhaps, behold a confused amorphous or nebulous mass, which the pair of eyes instantly shapes into delicate superimposed membranes, with intervening spaces, the thickness of which can be correctly estimated. Blood corpuscles, usually seen as flat disks, loom out as oblate spheroids. In brief, the whole microscopic world, as thus displayed, acquires a tenfold greater interest, in every phase exhibiting, in a new light, beauty and symmetry indescribable. J. L. RIDDELL.—*Silliman's Journal.*

On a new Method of illuminating Opaque Objects, for the high powers of the Microscope; and on a new Achromatic Condenser.—The front or terminal combination of the objective is made to condense light upon the opaque object by sending rays of light from behind, through the marginal border of the lens.

To accomplish this, a circular disk of fine plate glass, say near a fourth or fifth part as thick as the diameter of the lens, is bevelled on its outer margin, by grinding and polishing to an angle of 45°. A hole is drilled through the centre of the disk, of a diameter, say two-thirds, three-fourths, or four-fifths (dependent upon the angle of aperture), as great as that of the lens. The margin of this hole is also bevelled at an angle of 45°, down to a clean sharp edge. Both rings of bevels are on the same side of the glass, so that, if considered as projected, the lines would cross each other at right angles.

I find no insurmountable difficulty in giving an exquisite form and finish to these disks. I mount and revolve the disk on a good rose lathe; at the same time the grinding or polishing tool is revolved by an overhead motion, the spindle carrying the tool being mounted upon a slide-rest, and admitting of a protrusive movement at an angle of 45° to the axis of the lathe.

The disk, being finished, is to be placed centrally behind the lens, the bevelled margins looking backward, and the sharp inner edge almost or quite touching the lens. Parallel rays of light being thrown upon the disk, in the direction of the axis of the objective, from below in the direct, from above in the inverted microscope, a ring of parallel rays is sent, by two successive internal reflections, from the bevelled surfaces, so that, with direction reversed, the light traverses the outer margin of the objective, and by it is condensed upon the object in focus.

I tested this method of illumination in March last, sufficiently to be satisfied of its great value; more especially where the objective is of very short focal distance, and where consequently other means of illuminating opaque objects cannot, on account of the nearness of the objective to the object, be resorted to.

New kind of Achromatic Condenser suggested.

A larger, thicker, similarly bevelled disk, with the bevels on opposite sides of the plate glass, and their lines of inclination coincident, would probably serve as an efficient achromatic condenser of parallel rays. By attaching centrally, on the side opposite the bevel, achromatic lenses of proper size, or a good doublet combination, a most valuable form of achromatic condenser would I think be produced, useful for general microscopic illumination. I have not yet put the plan in practice. J. L. Riddell.—*Silliman's Journal.*

PROCEEDINGS OF SOCIETIES.

ZOOLOGICAL SOCIETY.

On the Structure of Echinococcus Veterinorum. By THOMAS H. HUXLEY, F.R.S.

December 14*th*, 1852.—The author described the structure of some large Echinococcus cysts with which the liver of a Zebra belonging to the Zoological Society was infested. The animal met with its death accidentally, having always appeared to be in good health and condition, though the cysts were very large and numerous, occupying a great portion of the substance of the liver.

The contents of the large cysts were free *Echinococci* and secondary *Echinococcus* cysts, contained in a clear fluid. The former were alive, and exhibited distinct, contractile motions. Attention was drawn to two important points in their structure, firstly, that the well known oval corpuscles were not calcareous, inasmuch as they were rapidly dissolved by acetic acid without effervescence, and were considerably acted upon by strong ammonia. The author supposed that they were albuminous, and that, both in these and the Tæniæ, the conversion into calcareous substance is an effect of degradation; and he pointed out their relations with the solid bodies in the integument of the Turbellaria, and with the so-called thread-cells of these and the Polypes. Secondly, that the peculiar wavy cilia, characteristic of a water vascular system, could be seen *in motion* in the living *Echinococci*. The cilia were described by Lebert in 1843, but the discovery seems to have been forgotten; it is, however, a point of great importance now that the existence of similar cilia in a definite water vascular system has been demonstrated in the other Cestoid worms.

The proper wall of the cyst (as distinguished from the laminated capsule) was traversed by a network of anastomosing vessels, to the points of union of which the fixed *Echinococci* were attached, the cavity of the pedicle of the latter appearing to be continuous with that of the vessels. It is in the cavity of the pedicle that Virchow observed cilia. The *secondary cysts* varied in size from 1-100th to 1-30th of an inch. The contained *Echinococci* were always of about the same size, and all the smaller secondary cysts possessed from one to four *Echinococcus* heads attached to their outer surface. The wall of the secondary cysts contains vessels like those of the primary one. In the larger cysts the external heads were found gradually disappearing, until they were quite smooth externally. When the secondary cysts were burst, their membrane continued to connect the heads, and formed the pedicle described by various authors. The formation of the secondary cysts takes place thus:—*Echinococcus* heads are formed over the whole inner surface of the cyst; this then becomes raised up at one spot by the development of *Echinococcus* heads, *outside* it also, and, gradually projecting inwards, and acquiring a narrower and narrower pedicle, it eventually falls into the cavity of the cyst as a free secondary cyst. The external heads of the secondary cyst (internal of the primary cyst) then gradually disappear; the internal ones (external of the primary cyst) remaining entire and in a normal state. The process is not essentially different from the ordinary germination of a *Tænia* or *Cysticercus.*

The author then endeavoured to show that the *Echinococcus* is nothing but the "*Scolex-form,*" to use Van Beneden's term, of a *Tænia*, retracted within itself, then greatly dilated and developing *Echinococcus* heads from its inner and outer surfaces, which are, however, like those of a serous sac, in reality both *outer.* It is the extreme result of modifications similar to those already undergone by the *Tænioid* type in *Cœnurus* and *Cysticercus.* The conclusion thus drawn on anatomical grounds is strikingly confirmed by the result of the recent experiments of Von Siebold, who fed young puppies with milk containing *Echinococci*, and, after a short time, discovered *Tæniæ* in their intestines.

The author then, in speaking of the literature of the subject, showed that the true nature of the *Echinococci* was fully understood by Goeze in 1782.

The paper was illustrated by numerous drawings.

Royal Society.

Thursday, March 17, 1853.—Two papers by Dr. Martin Barry were read; one on the subject of the ultimate structure of the muscular fibre, and of other tissues in animals and plants. The second on the occurrence of spermatozoa in the interior of the mammalian ovum. Dr. Barry's mode of viewing these subjects, but particularly, perhaps, the former, is doubtless well known to all our readers who may be interested in them, and neither paper presented anything at all novel or interesting, as they were, in fact, merely repetitions of the views first broached by Dr. Barry ten or eleven years ago; and an attempted vindication of them against the combined opinions of nearly all observers since that time. With respect to the former of these subjects, the only modification the author's views have lately undergone consists in this,—that whereas formerly the mystical double spirals perversely twisted themselves in opposite directions, they are now harmoniously contorted in the same.

Had it not therefore been partly from the circumstance of these papers being read at the Royal Society, whence they might be supposed to derive some extrinsic claim to attention, we should hardly have thought it worth while further to advert to them, or rather to the former of them,—but on this account, and also because Dr.

Barry's views have not long since been again produced under the respectable auspices of Purkinjé, and in the pages of Müller's Archiv. on the Continent, and in one of our most scientific periodicals in this country,—we have thought it right to say a few words on the matter. It is needless to enter into any discussion with respect to the supposed facts adduced by Dr. Barry—for the question, as one of fact, really admits of no discussion, and with respect to the worth of the speculations, founded upon these facts, it may suffice to observe that when Dr. Barry's views regarding fibre, contained in his paper in the Philosophical Transactions for 1842, were first promulgated, they met with the most direct contradiction from nearly every competent microscopic observer—at that time, however, not a numerous class, and that, in the interval which has since elapsed—and the ten years have produced a host of most competent histologists—they have found no support, or scarcely any, from any independent quarter, but, on the contrary, have almost invariably, when noticed at all, been described as "mythical and fantastical." The conversion or rather perversion of the venerable Purkinjé to these views seems to have taken place under the direct inspiration of Dr. Barry himself, and probably from examination of his preparations. Dr. Barry, it is true, also claims the support of Professor Agardh, given in his work on the structure of the cell-wall in certain Algæ; but it would be easy to show that Agardh's spiral structure, which moreover really relates only to the secondary deposits in the wall, has little or no connexion with the mythical double spirals of Dr. M. Barry. And we fancy that Professor Agardh would hardly deem it a compliment were he supposed to entertain the notion that the nucleus of a cell "resembles a ball of twine, which it gives off to weave the cell-wall!"—With reference to which we should be curious to see Dr. Barry's explanation of the formation of the cellulose wall around the primordial utricle in *Hydrodictyon*, for instance, when no nucleus, in the common acceptation of the term, exists at any time,—that is, no nucleus distinguishable from the rest of the primordial utricle.

In his paper Dr. Barry also quotes Dr. Allen Thompson as a believer in his views with respect to muscle. We have no information on the subject, but perhaps Dr. Allen Thompson may have since seen reason to doubt part at least of the premises upon which he was led to fall into Dr. Barry's views. His very high and deserved authority in questions of this kind would, at all events, render the knowledge of his present opinions most satisfactory.

With respect to the second paper, which consisted chiefly of a reclamation of Dr. Barry's priority in the discovery of the entry of the spermatozoa into the ovum, elicited apparently by some expressions in Dr. Nelson's most valuable paper on *Ascaris mystax* it is unnecessary here to say anything.

MICROSCOPICAL SOCIETY.

GEORGE JACKSON, Esq., President, in the Chair.

March 23, 1853.—A paper, by Dr. William Gregory, F.R.S.E., Professor of Chemistry in the University of Edinburgh, entitled 'Notice of a Diatomaceous Earth found in the Island of Mull,' was read. The author commenced by stating that this earth was discovered about two years ago by the Duke of Argyle, who gave a short account of its geological position to the Royal Society of Edinburgh. It constitutes a bed resembling marl in appearance, lying in a rough piece of ground at Knock near Aros, between Loch Baa, a fresh-water lake, and the sea. It is extremely rich in Diatomaceous remains, containing (according to a synopsis sent with the paper) various species of the genera Pinnularia Navicula, Gomphonema Amphora Stauroneis, Cocconeis, Surirella Cymbella Himantidium, Tabellaria Epithemia, Eunotia Cymatopleura, Synedra Fragilaria and Orthosira. Those most remarkable for their abundance are the genera Pinnularia Navicula and Stauroneis, and many of the species of these and of the other genera are of great rarity. After giving the chemical analysis, the Professor concluded by stating that the Mull deposit appears to him to be richer in Diatomaceous species, and perhaps in genera, than any other known deposit, there being at least 60 species and 16 genera enumerated as having been found in it. A portion of the earth and some slides containing specimens accompany the paper.

OBITUARY.

It is with the deepest feelings of regret we have to record the unexpected death of Dr. Jonathan Pereira, F.R.S., F.L.S., &c., at the age of 49, whilst in the prime of life and mental vigour. A few weeks previous to this occurrence, he had been to consult Professor Quekett on a scientific question; and whilst descending a staircase leading to the Hunterian Museum, made a false step, fell, and ruptured the rectus femoris muscle of both legs. In all probability, at the same time, some internal injury was sustained by the heart or larger vessels, but as only local inconvenience was experienced no danger was apprehended; but whilst getting into bed on the 20th of January, he felt a violent throb in the region of the heart, when he became fully aware that a speedy termination to his life was at hand, and this impression was verified within twenty minutes after. He was a man of portly bearing, with pleasing expression of countenance and great frankness of manner. Few men were possessed of such general and sound knowledge of subjects connected with his profession, and with so little affectation. He was an excellent observer in pharmaceutical microscopy and chemistry, and had a keen eye for what was practical; his literary judgment was very sound. He was author of 'Elements of Materia Medica and Therapeutics,' a work of universal reputation; the concluding portion of the third edition he was actively engaged on up to the time of his death. He also wrote 'A Treatise on Food and Diet;' 'Selecta è Prescriptis;' and 'Lectures on Polarised Light,' the best familiar exposition of that abstruse subject in our language. He also contributed numerous articles to societies, journals, reviews, &c. By his labours he rescued therapeutics from the chaos of hypothesis and absurdity in which it was formerly involved, and established it on a firm scientific basis. His death has left a void amongst European pharmaceutists which will not be readily filled. As a lecturer, he secured the attention of his class by an earnestness of purpose, aptness of experimental illustration, and the practical bearing of his remarks. He was a real friend to the student, to whom he was ever most liberal in affording assistance, often devoting valuable time in making him *thoroughly* acquainted with the subject of his studies. Dr. Pereira was, at the commencement of his medical career, apprenticed to a general practitioner, attended the Aldersgate Dispensary, became its apothecary, and lectured on Chemistry and Materia Medica. He afterwards became lecturer on these subjects at the Aldersgate School of Medicine, where his lectures attracted many students from the City hospitals. He subsequently lectured at the London Hospital, till about six years since. In 1840 he obtained the degree of M.D. Erlangen, and became a licentiate of the London College of Physicians, and was elected a fellow of that body in 1845. In 1841 he was appointed Physician to the London Hospital, which post he occupied up to the time of his death. He also lectured at the Pharmaceutical Society, and was Examiner on Materia Medica in the University of London. Though of good and affluent family, from reverses suffered by his father through unfortunate mercantile speculations he was obliged to make his way through the world unassisted, and he attained his high position in the profession entirely through his own industry and perseverance. He was a liberal advocate of popular education, and frequently lent his aid at our scientific institutions. He loved science for its own sake, and his name will ever be associated with those departments to which he devoted his labours; whilst those who were personally acquainted with him will long honour his memory.

DESCRIPTION OF PLATE III.

The letters refer throughout to the same or corresponding parts.

a. The Mucous Membrane of the mouth.

b. The Lip.

c. The Alveolus.

d. The Pulp.

e. The Dentine.

f. The Enamel.

g. The Basement Membrane of the Pulp.

*g*¹. Nasmyth's Membrane especially.

h. The "Enamel-organ" or Epithelium of the Capsule.

i. The Basement Membrane of the Capsule, with its subjacent condensed tunic. Hunter's inner, vascular, capsule.

k. The loose submucous cellular Tunic. Hunter's outer, non-vascular, capsule.

Fig. 1. Diagrammatic section of the inner incisor of the upper jaw of a Seven-months Fœtus. The loose enamel organ is indicated by * * * *.

Fig. 2. A cusp of the posterior molar, upper jaw of the same. The inner outline represents it before the addition of acetic acid—the outer afterwards, when Nasmyth's membrane is seen raised up into large folds.

Fig. 3. Edge of an incisor pulp—retaining its cap—not far from the lower edge of the dentine, which was about 1-1600th of an inch thick.

Fig. 4. Edge of the pulp of a molar cusp, showing the first rudiment of the dentine, commencing in a perfectly transparent layer between the "nuclei" of the pulp and the membrana preformativa.

Fig. 5. Surface of this dentine, where it had attained a thickness of 1-2500th of an inch, before which the little cavities, if present, were not visible.

Fig. 6. Nasmyth's membrane detached from the subjacent enamel by acetic acid.

Fig. 7. The "stellate-cells" of the human "enamel-organ."

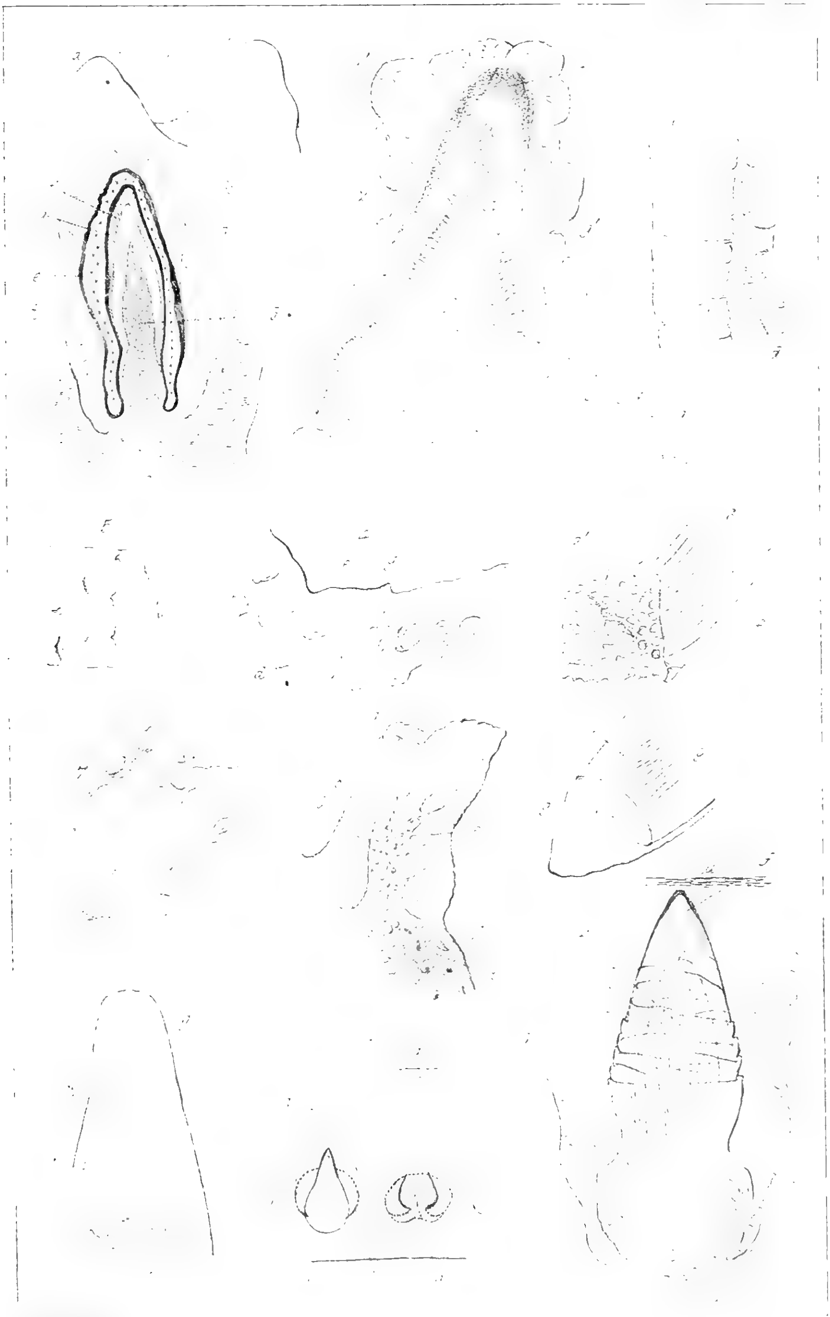
Fig. 8. Tooth of the Frog, acted on by dilute hydrochloric acid, so as to dissolve the enamel and free Nasmyth's membrane. The structure of the dentine is rendered indistinct. At the base Nasmyth's membrane is continued over the bony substance at *z*, in which the nuclei of the lacunæ are visible.

Fig. 9. Extremity of the tooth of a Mackarel, acted on by hydrochloric acid so as to dissolve the enamel. Nasmyth's membrane is rendered obvious, but is burst on the left-hand edge.

Fig. 10. Tooth-sac of a Mackarel, 1-50th of an inch long, extracted from its alveolus. Its close resemblance to a hair-sac is very striking.

Fig. 11. Diagrammatic section of the dental follicles of a Skate, to show the union of the upper and lower folds of the "dental groove."

Fig. 12. Extremity of a dermic, tooth-like spine, from the upper surface of the head in the Skate, acted on by hydrochloric acid, which has removed the layer of enamel.



DESCRIPTION OF PLATE VII.

These Positive Photographs from Collodion Negatives, taken by J. Delves, Esq., illustrate that gentleman's, Mr. Shadbolt's, and Mr. S. Highley's papers on Photography.

Fig.

1. Spiracle and Tracheæ of the Silkworm, magnified 60 diameters, exhibiting the elastic spiral fibre between the layers of the air vessels.
2. Proboscis of the Fly, magnified 180 diameters, showing the divided absorbent tubes.

DESCRIPTION OF PLATE VIII.

On the Starch-granule, *by G. Busk, Esq.*

Fig.
1, 2, 3, 4, 5. Various forms of starch-granules in "Tous les mois" Arrowroot.
6. Granules beginning to expand.
7, 8, 9. Farther progressive stages of expansion of the granule of "Tous les mois."
10. Various forms of starch obtained from the Horse-chestnut (*Æsculus hippocastanum*).
11, 12, 13. Granules of the same starch acted upon by sulphuric acid.

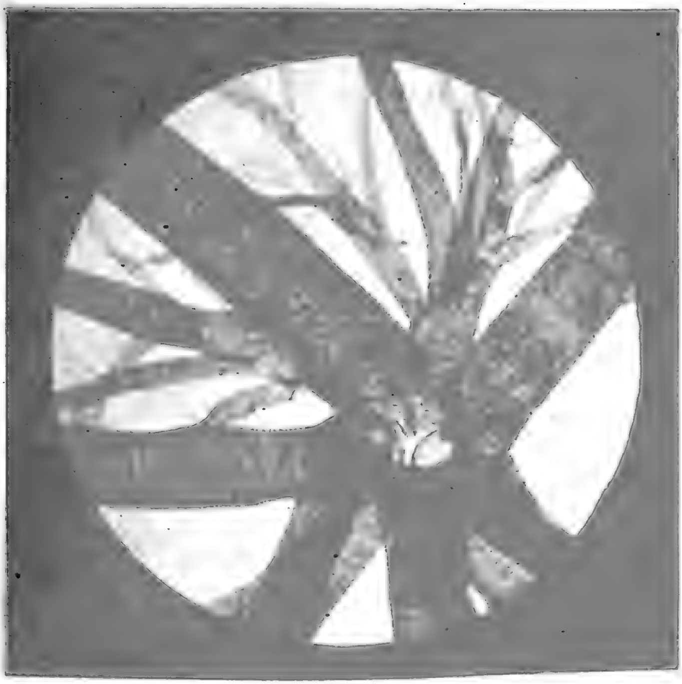
DESCRIPTION OF PLATE IX.

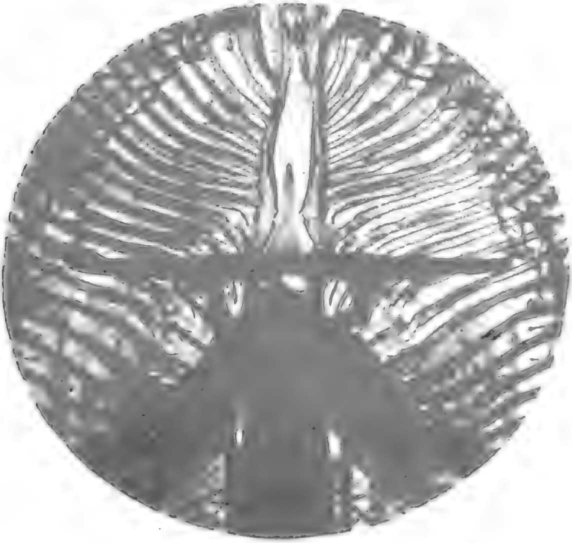
On Asteridia in Confervæ, *by the Rev. W. Smith.*

1. Filament of *Zygnema quininum*, Ag., containing *Asteridia* in various stages of development.
2. } 3. Filaments of *Mesocarpus scalaris*, Hass., var. β, in conjugation, and containing *Asteridia*.
4. Filament of *Zygnema quadratum*, Hass., in conjugation.
5. Filament of the same containing an *Asteridium*, and another a reproductive spore.
6. Filament of the same, showing a double mode of conjugation in the same species.

On a Fungus in an Oak Tree, *by Prof. E. J. Quekett.*

7. A portion of an oak tree, showing a fungus and masses of crystals, *in situ*.
8. Fungus magnified 150 diameters.
9. Large crystal, having fungi in its interior.
10. A portion of fungus seen within a crystal.





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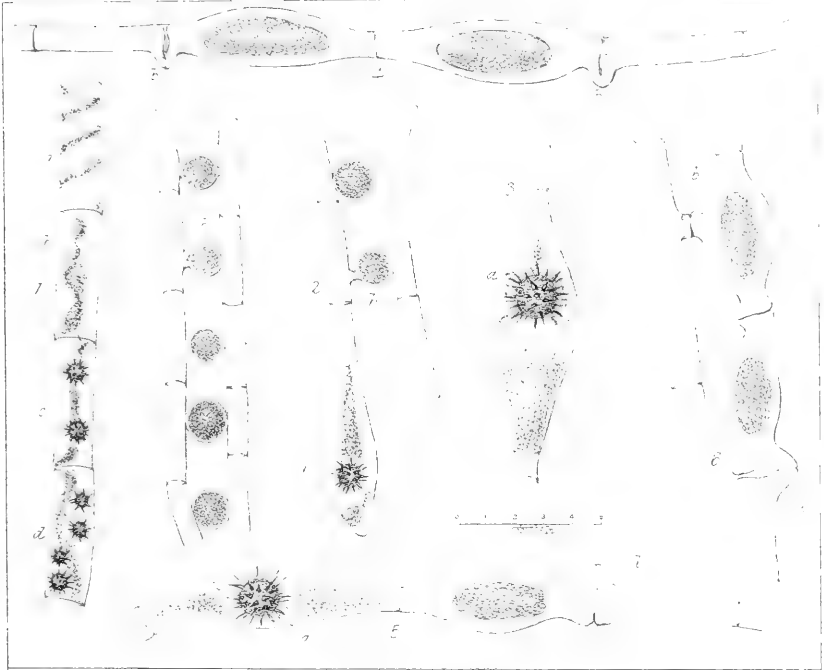

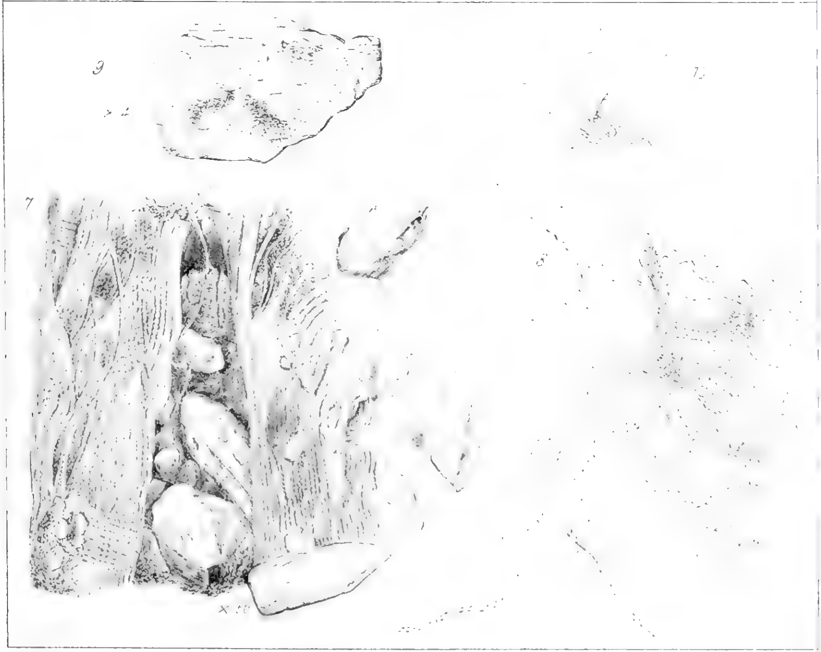

Tuffen West, sc

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ORIGINAL COMMUNICATIONS.

On the genus Triceratium, with Descriptions and Figures of the Species. By T. Brightwell, F.L.S.

The genus *Triceratium*, with several other genera of Diatomaceæ, was established by Ehrenberg in a Memoir communicated by him to the Berlin Academy in 1839-1840.* He founded it upon two species, described and figured in the Memoir, *T. favus* and *T. striolatum*, the former of which is commonly taken as the type of the genus.

Several new species were afterwards described by Ehrenberg in the monthly reports of the Berlin Academy, most, or all of which, are given in Pritchard's 'History of Infusorial Animalcules,' ed. 1852, pp. 448, 449, and in Kutzing's 'Species Algarum,' 1849, pp. 140, 141, but no figures have been given of these species. Professor Bailey, of New York, has described and figured one or two species discovered by him.

We purpose, in the present memoir, to give descriptions and figures of the known species, and to add some others which have hitherto been unnoticed.

The *Triceratia* are all marine. We have detected nearly all the recent species described in this memoir in material obtained from the surface of the large sea-shells of the genera *Hippopus* and *Haliotis*, before they have been cleaned. Many of them, in this state, are covered with small zoophytes, minute algæ, and other parasites, and by a careful examination of these, *Triceratia* and other Diatomaceæ have been obtained.

I have been indebted for a supply of one new and interesting species, collected by Dr. Sutherland in the Arctic Regions, to Dr. Baird of the British Museum. It is noticed as '*T. striolatum*, Ehr.,' in the appendix to Dr. Sutherland's 'Journal of his Voyage in Baffin's Bay and Barrow's Straits,' 1850-1851, vol. ii. pp. cxcv-cxcix. 'Diatomaceæ.' Having, by the means above mentioned, obtained a good supply of *T. striolatum*, and finding it to be clearly distinct from the arctic one, I have named the latter *T. arcticum*. Dr. Suther-

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* Über noch jetzt zahlreich lebende Thierærten der Kreidebildung und den Organismus der Polythalamien. Von H^{rn} Ehrenberg. Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, 1839, p. 81.

land has given the following note with this species—"Taken from a depth of fifteen fathoms, shingly bottom, calcareous district. Temperature of the water 31°.8; covered with ice for nine months of every year. Union Bay, Beechey Island, lat. 74° 43′; long. 92° W. September 4th, 1850."

The frustules of this species were found in a mass unmixed with any other Diatomaceæ, and very much broken. Many of the perfect frustules have the endochrome in them, and when examined as first received, had very much the appearance of being attached to a minute alga found among them. This is, I believe, the only instance in which a large number of living frustules of Triceratia have been found isolated, and almost compacted together. Among the *Diatomaceæ* collected by Dr. Sutherland in other parts of the Arctic Seas, I have found a few frustules of *T. arcticum*, but these occur, as do most of the other species, sparingly. I have not been able to detect among all the specimens of *T. arcticum*, furnished me, a single one, in which the fissiparous division appears to have commenced; all the specimens are, however, nearly equal in size, and agree in form and structure, not presenting any of the variations which I have noticed in *T. striolatum*, and in one other species as hereafter mentioned.

Ehrenberg has given elaborate figures of the end and front view of *T. striolatum*, in the memoir above mentioned, but he has not noticed any varieties of this, or, I believe, any other species.

The general form of *T. striolatum*, on an end view, is triangular, but I have found among the frustules obtained, from the shells above mentioned, several specimens of a pentagonal form, and having the appearance of being composed of a number of pentagonal plates, united together. The colour and sculpture of these five-sided frustules is precisely the same as that of the triangular ones. I have also detected another variety of a cubical form, presenting nearly a perfect square on the end view, and agreeing in colour and sculpture with the triangular specimens. I have not met with variations of this kind in any other species except in *T. scitulum*, mihi, a small species in which the surface is marked with large hexagonal cells, and in this species I have detected a variety with four concave sides on an end view, of which I have given a figure. Among the specimens of *T. favus*, obtained from Thames mud, I have found one presenting a very remarkable singularity. A semi-circular arch is hollowed out of the centre of the end walls, having a regular arched rim of square cells around it, resembling the key-stones of a bridge, and leading to the conclusion that the frustule, in its formation, meeting with some impediment, had formed its walls around it.

These variations in form appear to me to confirm the view now generally taken of the vegetable character of the *Diatomaceæ*, while, on the other hand, they are in opposition to the general law regulating the multiplication of the species. Such forms could not proceed from a spontaneous longitudinal division, in which each half produced a counterpart of itself. They are perhaps the result of that specific mode of reproduction to which Mr. Smith has alluded in his valuable papers on the Diatomaceæ, in the 'Annals of Natural History' (series 2nd, vol. ix. p. 5). In this mode of reproduction it is quite possible that abnormal variations of form may take place.

For some excellent observations on the structure, mode of growth, and general physiology of the Diatomaceæ, I beg to refer the reader to the above-mentioned paper by Mr. Smith, and particularly to that contained in the 'Annals,' series 2nd, vol. vii. pp. 1-5, and also to his Introduction to his most useful 'Synopsis of the British Diatomaceæ,' the first volume of which has been recently published.

Nearly one-half of the described species of Diatomaceæ are fossil, the greater number being found in the Bermudas. Several of the fossil forms are also found among the living species. One of the difficulties attending the study of this genus, and the determination, especially in the fossil forms, of the species, arises from the difficulty of obtaining perfect frustules, and examining them in their front aspect. The imperfect frustules present only the end or triangular wall, from which alone no perfectly satisfactory specific character can be obtained. For this reason several of the species here described and figured must be adopted only provisionally, *i. e.* till perfect frustules can be examined.

Many of the species also vary extremely in size. I have observed this to be the case with nearly all the species of which I have had an opportunity of obtaining many specimens. In *T. striolatum* and *T. alternans*, and in the latter both in the recent and fossil specimens, the variations in size are such as force one to the conclusion that they have been formed by conjugation of frustules, or some mode of reproduction varying from that of self-division. In the outline figures of varieties of *T. striolatum* (Pl. IV., fig. 11), will be found two, in which small frustules are adhering to larger ones, as if they were budding or growing from them; this whole group were gathered from a shell of *Hippopus* *maculatus*, and are figured as they appeared, lying in a watch-glass, with a little water over them.

The species of the genus *Triceratium* may, for the most part, be recognised by the triangular form they present, on an end view of the frustules. The normal form of the frustule may be represented by a vertical section of a triangular prism. If the frustule be placed upon one of its flat sides, we look down upon its ridge and obtain a front view of its two other sloping sides. If it be placed upon one of its ridges, we have a front view of one of its flat sides, generally broader than long, and of its smooth or transparent suture, or connecting membrane. If the frustule be progressing towards self-division, it is then often considerably longer than broad, and when nearly matured for separation, presents the appearance of a double frustule.

A simple frustule, when dissected or broken up, consists of two triangular plates or walls of silex, forming the ends, and of three oblong rectangular pieces or bands, forming the three sides; the latter usually dividing themselves into several elongated paralleliform pieces. These siliceous plates themselves are formed of several distinct layers of silex, dividing, like the thin divisions of talc, and are frequently found of such exquisite delicacy as to be difficult of detection.

Synopsis of the Species.

Section I.—*Sides concave with the angles protruded. Valvular cells minute.*

1. *T. Solennoceros*, Ehr. Sides deeply concave. Angles extended into long arms rounded off at the ends. Cells radiating in straight lines to the extremity of the arms. Diam. 1-276th.

Fossil, in Bermuda earth. Perfect specimens of this singular and beautiful species are rarely found. Ehr. describes the arms as tubular.

Kutzing, Species Algarum, p. 140.

Plate IV., fig. 1.

2. *T. brachiolatum*, mihi. Sides concave. The angles extended into short arms, rounded at the ends, which are perfectly smooth, while the rest of the valve is covered with minute cells. Diam. 1-250th.

New Zealand. Recent; from the cleanings of shells and small algæ. Rare.

Plate IV., fig. 2.

N.B.—This species appears allied to *T. pileolus*, Ehr.; but is much larger, and probably distinct.

3. *T. tridactylum*, mihi. Sides concave. Angles carried out into a distinct papilliform extremity. Surface of the valves covered with minute cells. Diam. 1-318th.

Fossil, in Petersburg earth, N. A. Rare.

Plate IV., fig. 3.

Section II.—*Sides straight, or somewhat convex.*

a, Surface with large hexagonal cells.

* *Angles spinose.*

4. *T. comtum*, Ehr. Sides straight. Angles extended into a short stout spine. Sides of the angles with a projecting fringe, the fringe having a row of oval depressions. Surface covered with large hexagonal cells. The edge of the fringe is sometimes broken off, leaving the appearance of small spines. Diam. 1-218th.

Kutzing, S. A., p. 140.

From the cleanings of Tridacnidæ and other shells.

Plate IV., fig. 4.

5. *T. muricatum*, mihi. A minute species. Sides straight. Angles ending in a stout spine. Front view nearly square, resembling an Odontella or Zygoceros. Diam. 1-583rd.

From the cleanings of Tridacnidæ and other shells.

Plate IV., fig. 5, *a*, *a*, front view; *b*, end view.

6. *T. spinosum*, Bailey. Sides furnished with 4 lateral setæ.

Kutzing, S. A., p. 141.

In North America; a doubtful species. No figure has been given of it, and I have not seen a specimen.

* * *Angles not spinose.*

7. *T. favus*, Ehr. Angles having an obtuse projection. Cells on the surface large, and the hexagonal figure of them well defined.

Kutzing, S. A., p. 140. Diam. 1-200th to 1-150th.

Smith's 'Brit. Diatomaceæ,' vol. i., p. 26; plate v. 44, end view; and supp., plate xxx. 44, front view.

Thames mud, at the junction of the Yare and Waveney, near Yarmouth. This species appears pretty generally distributed. I have found it on shells, from various regions, and fossil in Petersburg earth, N. A.

Plate IV., fig. 6. This figure presents the remarkable formation noticed before.

8. *T. megastomum*, Ehr. Sides straight. The hexangular cells smaller and more delicate than in T. favus. Diam. 1-350th to 1-175th.

Kutzing, S. A., p. 140.

Allied to T. favus; but distinguished from it by its smaller size, more delicate structure, and sharp triangular form.

Found in Ichaboe and other guano, and among the cleanings and small algæ from foreign shells, varying much in size.

Plate IV., fig. 7.

9. *T. grande*, mihi. The largest and stoutest species of this genus. Sides convex. Angles attenuated, obtuse. Hexagonal cells numerous.

Found on Tridacnidæ and other shells from the Indian Seas, not unfrequent. Diam. 1-100th.

Plate IV., fig. 8.

Ehrenberg has described a large species (*T. ocellatum*) from the Indian Seas. See Kutzing, S. A., 141; but his description differs altogether from the present one.

10. *T. scitulum*, mihi. A small species, but varying in size; on some of the frustules I have reckoned on an end view, about 45 cells only; very slightly convex on the sides. Angles open. Diam. 1-350th.

From the cleanings of shells from the Indian Ocean.

Plate IV., fig. 9; *a*, end view.

Var. *β*. Having four concave sides. I have detected this curious variety on several occasions.

b. *Cells very small.*

11. *T. striolatum*, Ehr. Frustule on a front view longer than broad with the ends deeply concave, transparent; colour, pale brown. The whole, under a high magnifying power, delicately marked with minute cells. Diam. 1-290th.

Kutzing, S. A., p. 140.

Var. *β*. Frustule pentagonal; end view quinquangular; each angle concave.

Var. *γ*. Frustule cubical; end view square.

Recent: found among the small Algæ, &c., on *Hippopus maculatus*.

Plate IV., fig. 10. *a*, front view; *b*, end view. Fig. *c*, pentagonal frustule; *d*, square ditto; *e e e e*, various aspects of the frustules.

12. *T. arcticum*, mihi. Front view broader than long, with the ends straight; clearly distinct from the last species. Diam. 1-250th.

Beechy Island, Arctic Regions, Dr. Sutherland: and sparingly among Diatomaceæ from other parts of the Arctic Seas.

Plate I., fig. 11. *a*, front view; *b*, end view.

13. *T. condecorum*, Ehr. Sides nearly straight, or slightly convex; angles slightly rounded off. On an end view the rows of the cells diverge from the centre in elegant curved lines. Diam. 1-384th.

Kutzing, S. A., p. 140.

Fossil in Bermuda earth.

Plate I., fig. 12.

14. *T. undulatum*, Ehr. Sides undulated; three or four undulations on each side. Angles pointed. Cells radiating in lines from the centre of the valve. Diam. 1-480th.

Kutzing, S. A., p. 140.

In all the specimens I have seen, the posterior plates of silex project beyond the undulations of the front plate, giving this species a unique aspect.

Fossil, in Bermuda earth.

Plate IV., fig. 13.

15. *T. amblyoceros?* Ehr. Sides convex; very slightly undulated. Angles rounded off. Posterior plates not conspicuous.

Pritchard's 'Infusoria,' 1852, p. 448. Fossil, Richmond, Virginia. Diam. 1-456th.

Plate IV., fig. 14.

16. *T. membranaceum*, mihi. Walls of the frustule extremely delicate; sides convex. Angles attenuated, ending in minute papillæ. Frustule dotted over with very minute cells. Diam. 1-233rd.

From the Thames mud. Rare.

Plate IV., fig. 15.

17. *T. acutum*, Ehr. Sides straight or slightly convex, and drawn to a point more or less lengthened out. Diam. 1-720th.

Surface with irregular cells.

Kutzing, S. A., p. 140.

Plate I., fig. 16.

Fossil, in Bermuda earth; varying much in form.

18. *T. reticulum*, Ehr. A minute species. Sides straight. Cells small and somewhat irregular. Front view twice as broad as long. Suture narrow. Ends round, projecting, somewhat like a Biddulphia. Diam. 1-388th.

Kutzing, S. A., p. 140.

Fossil, in Bermuda and Richmond earth, and recent from shell cleanings and small algæ.

Plate IV., fig. 17. *a*, end view; *b*, front view.

Section III.—*Ends of the angles entirely rounded off.*

19. *T. Montereyii*, mihi. Ends of the angles enlarged and bluntly rounded off. Structure of the frustule stout. End wall elevated in the centre of the triangle, with the cells in that part stouter, and gradually diminishing in size to the sides and ends, where they nearly disappear. Diam. 1-300th.

Fossil, in a stratum of earth occurring near the shore of Monterey Bay, N. A., abounding in Diatomaceæ. Furnished by Mr. A. J. Taylor, of Monterey.

Plate IV., fig. 18.

20. *T. alternans*, Bailey. Ends of the angles divided from the rest of the valve by a transverse line. Cells circular. Diam. 1-500th.

Bailey's 'Microscopical Observations made in S. Carolina,' &c., p. 40; and 'Soundings,' fig. 55, 56. Smith's 'Synopsis Brit. Diatom.,' p. 26; plate v. 45; plate xxx. 45.

On the shores of the British Atlantic and Pacific Oceans.

Fossil in several of the Diatomaceous earths from North America and from Monterey, and in Peruvian guano.

This well-defined species varies greatly in size, both in the recent and fossil states.

Plate IV., fig. 19. *a*, front view; *b*, end view.

21. *T. obtusum*, Ehr. Sides straight or somewhat concave. Ends rounded off. Cells small; irregular. Diam. 1-700th.

Kutzing, S. A., p. 140.
Fossil, in Bermuda and Richmond earth. Recent in Thames mud.
Plate IV., fig. 20.

22. *T. semicirculare*, mihi. Ends rounded off, and one end so much so, as to reduce the frustule to a semi-circular figure.

Fossil, in Bermuda earth, not uncommon, about the size of the last species, but varying in breadth.

Plate IV., fig. 21. A narrow variety.

In the preceding arrangement of species we have indicated characters of division which must be received with caution. It is remarkable how, in these minute and obscure organisms, we find ourselves met with the same difficulties, as to any positive laws governing the formation of any generic types, as in the larger and more complex forms of animal and vegetable life. It appears as if we could carry our real knowledge little beyond that of species, and, when we attempt to define kinds and groups, we are met on every side by forms which set at nought our definitions. With reference to the species of the present genus, looking upon *T. favus*, or *megastomum*, as what we conceive to be the most perfect plan (if any) on which this group is constructed, we find all the species diverging from it, and carrying us to analogous forms in other groups, or lost in them. Placing the perfect triangular form of *T. favus* in the centre, we may diverge in lines to a circumference ending in one line, in the long-armed *T. Solennoceros;* itself nearly resembling *Desmidium tridens*, or *hexaceros*, Ehr.; in another line ending in a form resembling *Desmidium apiculosum;* in another like *Zygoceros rhombus*, especially in the front view; in another analogous to *Amphitetras antediluviana;* and in another to *Campilodiscus cribrosus*.

Norwich, June, 1853.

On certain Appearances occurring in Dentine, dependent on its Mode of Calcification. By S. James A. Salter, M.B., F.L.S., &c.

In Kölliker and Siebold's *Zeitschrift* for 1850, Czermak published a paper, on some points of the minute anatomy of the teeth, whose importance has not, as it seems to me, been sufficiently appreciated in this country. No abstract or translation of this paper has yet appeared in English, though the interest and value of its contents probably equals any single other that has appeared since the earlier writings of Purkinje and Retzius.

Czermak, among other interesting matter, has been the first, in this communication, to give a correct explanation of those curious appearances of globular, conglomerate formations in the substance of dentine, which have been so long an enigma to some of our most indefatigable microscopists.

My object in the present communication has been partly to give a summary and confirmation of Czermak's paper, in reference to certain points in the anatomy of dentine, and partly to add some further observations of my own on the same subject and in the same direction.

The peculiar markings on dentine, known as the "*Contour lines*," and their appendages, the irregular patches of small interspaces which limit the outer extremities of the contour lines, have never received a rational explanation until the publication of Czermak's paper; and the latter appearances especially have previously been the subjects of the most far-fetched and untenable interpretations.

The peculiar patches of opaque interspaces, and the globular masses of dentine which bound them, have been shown by Czermak to be dependent on the mode in which the animal material of dentine is calcified, and to a certain extent (though I think not sufficiently) he attributes the contour lines to the same cause. At all events they are obviously associated and produced at the same time and under the same conditions of nutrition, and must be considered together.

The appearances in question are found variously disposed in different teeth and in different proportions in different specimens. It may be remarked, however, that they are always most conpicuous in those teeth whose *enamel* exhibits irregular development; and in making sections this may be remembered for the purpose of selection. It will be found, moreover (as I shall presently explain), that there is an obvious relation in number and position existing between the contour markings in the dentine and the grooves and irregularities on the enamel—a fact which I have not seen mentioned, though I believe it to be uniform. Czermak has, however, pointed out another circumstance not previously described, by which this condition may be recognized in the entire tooth—it is the appearance of *opaque white lines around the fang, forming white rings:* this can be best seen by moistening the tooth for a minute and then holding it obliquely by the side of a bright light. These rings, which vary in breadth from the 1-50th to the 1-100th of an inch, are scattered in succession from the neck to the apex of the fang: their white opacity contrasts remarkably with the darker, semi-clear, yellower intermediate portions of the fang. These rings are, of course, abnormal: their number varies: I have one tooth—an inferior canine—in which there are thirteen rings strongly marked. Of the import of these rings I will speak hereafter.

When, then, a well marked specimen (such as I have represented at Pl. V., fig. 1) is examined with a low power, the arrangement of the contour markings* will be seen as follows:—I would, however, first observe that the section should be vertical, and of an entire tooth; for if it be only of a portion of a tooth, the relative position and direction of the markings in the different parts of the organ cannot be seen, and these circumstances are of the first importance for comprehending the import of the appearances in question.

The term "contour lines" originated with Professor Owen, I believe, and implies the general similarity which these have with the contour of the tooth. The contour of the two, however, is not identical, for the markings (in whatever part examined) are more divergent than the outline of the tooth; and, passing from within outwards, abut in succession upon the external surface of the dentine. In comparing the absolute contour of any tooth, it will be found that the angle formed by its sides is more acute at its summit, or the summit of any particular cusp, than the contour markings within.

In viewing the specimen with transmitted light, it will be seen that a series of dark opaque granular patches are arranged immediately within the enamel and crusta petrosa in the outer portions of the dentine. In the crown of the tooth they are usually more distinct and definite than in the fang: they are not continuous and do not form an uninterrupted layer, but are separated from each other by intermediate portions of normal and well-formed dentine. These patches are more or less club-shaped, with the butt-end of the club towards the surface, and the pointed or attenuated end stretching obliquely inwards and upwards towards the pulp cavity. These patches are so irregularly defined that, unless viewed with very low powers, their outline can scarcely be said to have any describable shape. When, however, they are slightly magnified, or seen without a microscope at all, they appear to be convex on the outer and upper margin, and straight on the opposite side. The upper margin and outer extremity are the darkest and most defined; the lower margin and inner extremity are jagged and ill-defined. The little elements of the patch are very interrupted towards the inner extremity, but are scattered in a

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* I employ the term "*contour markings*" in preference to "contour lines," because I intend thereby to include the opaque granular patch at the outer limit of the lines, as well as the lines themselves—they are essentially one in cause and meaning.

direction upwards and inwards and are lost. The contour marking is then taken on by a dark linear streak, which passes nearly in the same direction as the patch, with a slight curve, towards the pulp cavity. The nature of this line does not appear with low power; it merely looks as an opaque streak, more or less dark and defined. The *patch*, as I have observed, is most marked near the surface of the tooth: the *line*, near the pulp cavity; and where they join they are both indistinct, and sometimes not to be discerned. The relative *direction* of the contour markings is curious and interesting, and the examination of it in the different regions of the tooth is particularly important. Czermak does not notice this: indeed, his figure, drawn to display the general arrangement, only exhibits a very small portion of the tooth—not enough for the purpose—and what is shown is faulty, and only approximative.

For the particular description of the course of a contour marking, I will select the region just below the neck of the tooth; they are there peculiarly indicative of their character and meaning. In passing from the surface of the tooth to the pulp cavity, the contour marking makes a double curve, like the letter *f*, and precisely resembling the primary curves of the dentinal tubes in that region. In passing from without inwards the first curve presents a convexity outwards and upwards, then bending in the opposite direction, the convexity looks inwards and downwards, and as the line almost reaches the cavity within, the curve still continuing, it passes almost perpendicularly up the side of the pulp cavity, sometimes apparently joining the line above it. Now it will be seen that the curves of the contour marking not only resemble the primary curves of the dentinal tubes in a general way, but that they are exactly the same in amount at any particular spot, and always opposite in direction: as the tubes bend in one direction the contour markings bend in the opposite, so as to cross the former almost strictly at right angles; and this may be stated as a rule—*that the curves of the contour markings are in proportion to the primary curves of the dentinal tubes at any particular spot, and cross them at right angles.* This may be seen by reference to fig. 1. In the crown and fang the contour markings are simpler and less curved. In the crown they are more horizontal and, passing above the pulp cavity, meet over its summit: here the markings are very short. In the fang they are almost vertical, and nearly parallel with the inner and outer surface of the dentine. The lower ones are usually very ill marked, and though they can be traced for a long distance up the fang, as they slowly approach the pulp cavity, they are indistinct and interrupted.

Contour markings vary in intensity and number: they are most abundant in the root and most marked in the crown. In the root, though very numerous, they are often scarcely visible. In the crown, when the line is well marked, it is always bounded externally by the opaque patch; but between these there are frequently others less marked—in such instances, lines without patches at their extremities.

In teeth, with more than one cusp, the upper contour markings are confined to their own cusps, and their extremities abut against the sides of those cusps; but the succeeding ones join the markings of the contiguous cusps.

The contour markings are also well seen in a transverse section of a tooth, especially about the neck. Here they are represented by a series of concentric rings—a horizontal section cutting the successive markings at different distances from the pulp cavity. In this view Czermak likens them, not inaptly, to the year-rings in wood.

I would here observe that the contour markings are dark by transmitted light, and opaque white by reflected. When mounted in Canada balsam, with continued heat, so as to allow the specimen to soak in the fluid resin for some time before it cools, or when mounted in some liquid, the reverse is the case. The same also happens when decalcified specimens are mounted wet. It is the white opacity of the extremity of the contour markings that produces the appearance of rings on a tooth fang, already referred to.

Decalcified specimens exhibit further points concerning the contour markings. In preparing these specimens I first make the section accurately, as though for mounting in the ordinary way; I then decalcify it by submersion in dilute muriatic acid. It is impossible to make even and regular sections by cutting the softened tooth, and I therefore always make the section before I decalcify it.

A vertical section thus prepared will be seen to exhibit the contour markings strongly. If such a specimen be hooked about with needles, so as to break it up, it will be found to tear in successive portions in the direction of the contour markings, the tear usually being the line of the marking itself. By this means the specimen may be broken up into a series of triangular portions—the triangles being formed by the external surface of the dentine and any two neighbouring contour markings; the base of such triangles is outwards, and the attenuated apex is inwards, and drawn up the sides of the pulp cavity. These triangular slips thus produced are the intermediate portions of normal dentine, situated between the contour marking. Even the well formed dentine tears readily, but it is parallel with, and in the same direction, as the contour markings. Transverse sections decalcified break up into a series of concentric rings, beautifully and exactly regular: it is not easy to tear out complete rings, but they are partially separable, and are indicated in great numbers; indeed their number seems to be limited only by the mechanical means employed to isolate them. Such a specimen is exhibited at fig. 2. Now, the breaking up of a vertical section into triangular imbricated slips, and of a transverse section into a series of rings, is tantamount, in the entire tooth, to a stratified or laminated arrangement: indeed, considering these circumstances, as they bear upon the solid tooth, they indicate its composition (in one point of view) as a series of *hollow cones* adapted one upon the other.

Czermak notices the stratification of the dentine, and speaks of the strata being loosened from each other: he says, "I have succeeded in breaking off whole layers of tooth-substance, which had perfectly smooth surfaces." He considers that the splittings of the tooth-substance are by no means a resolution of the structure into its original elementary parts. He further says,—"The ground substance has certainly a stratified composition, but this is usually latent, as it were." It is fair to observe that the lamellation of dentine, as exhibited in decalcified teeth, was first pointed out by Dr. Sharpey,* in the tooth of the Cachalot whale. It is most readily seen in the teeth of large mammalia (elephant, hippopotamus, &c.), but its import is better understood in smaller teeth, where its relation to the entire organ can be contemplated at once.

I may here point out a fact which, if it have been noticed, has, I believe, hitherto escaped recording; at least it has never been distinctly expressed. It is, that the contour markings, as well as the fracture lines, which so readily occur in the intermediate normal dentine, and are parallel to them, exactly correspond to the pulp surface in the progressive formation of the dentine—are identical in fact with the junction line of the pulp and internal dentine surface at any particular time of growth. In contrasting such a section as is exhibited at fig. 1, with a series of one-cusped teeth in different stages of advancement, this will easily be recognised: the portions of dentine seen between the contour markings in viewing the tooth from above downwards are, as it were, the successive increments by which the organ is built up, and by which the original expanded cap of dentine as it first appears, is converted into an elongated cylinder with a tube up the centre.

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* Quain and Sharpey's Anatomy, p. 978.

I have dwelt thus much upon this point, as I have presently to show how the contour marking is produced by a condition common to the entire growing surface of the dentine at one time.

Having said thus much of the general arrangement of the contour markings, I will describe their anatomy as displayed by higher microscopical scrutiny.

Two hundred diameters will suffice for the magnifying power. When the patches are thus examined they are seen to consist of globular masses of dentine more or less isolated by interspaces, as they are less or more confluent one with another. The dentine globules ("tooth-substance-balls," as Czermak calls them) are spheres, hemispheres, or partial spheres, usually of normal dentine, and traversed in the usual way by dentinal tubes. Their size varies immensely—from 1-400th, 1-300th, or even 1-250th of an inch, down to particles of granular dimensions; even 1-10,000th of an inch in diameter; indeed there seems no limit to their minuteness. When cleanly mounted the outline of the globules is beautifully sharp. The interspaces between them vary in form according to the number and size of the globules that bound them. In contemplating a large interspace one sees the globules and partial spheres bulging into it, some bright and clear, others looming indistinctly out of focus. Sometimes the interspaces are reduced to mere semi-lunar lines of extreme tenuity. These appearances are represented in fig. 3. Dentine globules are largest in the crown of the tooth, and smallest in the fang, especially near the cemental surface: indeed, in the latter situation, in passing from the surface towards the pulp cavity they regularly enlarge, but while they increase in size they become more fused together, the globules are less spherical, and the interspaces proportionally smaller.

I would here remark that the interglobular spaces (as ordinarly observed in teeth extracted, allowed to get dry, and subsequently cut into sections) are truly hollow and filled with air. This Czermak has enforced.

The relation which the dentinal tubes have to the dentine globules and the interglobular spaces, is interesting and remarkable. The globules are permeated by tubes exactly as the other dentine: the face of a large globule sometimes exhibits as many as five or six tubes traversing it. Now, in following an individual tube across a mass of globules, one observes it follow a regular course, just as if there were no interspaces: one follows the tube across one globule, then, skipping the interspace, one finds it crossing the next globule in a line with its position in the first, and so on. There seems an evident continuity. In specimens, in which the interglobular spaces have been filled with Canada balsam, I have seen (as I have believed) the dentinal tubes collapsed upon the sides of the interspace, establishing the continuity. Kölliker has seen more than this; for he says, that in decalcified specimens the interglobular spaces are sometimes filled with a soft substance, which is traversed by tubes, and "these may be entirely isolated like the dentinal tubes." Though I have looked for these I have not seen them, but of the fact I cannot doubt when stated by such an authority, especially as I have observed what amounts to the same in a different phase.

The linear portion of the contour marking is explained in four ways:—First, by a series of secondary curves in successive dentinal tubes; secondly, by the dentinal tubes being locally widened; thirdly, by interglobular spaces. The two first, though producing the same general appearance when seen with low powers, are, I believe, essentially different from the contour marking dependent on abnormal calcification.

The interglobular spaces, which form the contour line, are usually a few scattered semilunar streaks, when seen with high power: sometimes these become confluent, and they then form a narrow linear interspace, not wider than a dentinal tube. This latter I have not seen described. Not unfrequently, however, it is impossible to find any anatomical change, even when examined with the highest power, in the dentine that exhibits a contour opacity; and I can only imagine that a difference in density of such a layer relative to contiguous layers, probably dependent on its composition in the amount of earthy and animal matter it contains respectively, may possibly produce it. Such an explanation is quite in keeping with the rationale of the other element of the contour marking.

The explanation of globular dentine, and indeed of all the circumstances of the contour markings, is to be sought, and is to be obtained, by examination of the pulp, or inner surface of the dentine, especially of growing dentine. This is the great point of Czermak's paper.

To obtain a specimen for examination, Czermak directs that a tooth (not completely formed) should be split, and then the section ground from without inwards until sufficiently thin, the pulp surface never being allowed to touch the stone; the preparation is then to be mounted, with the inner, unrubbed surface supine. The appearance of such a specimen is thus graphically, and, as I can testify, most accurately described by Czermak:—

"The tooth-substance appears then on its inner surface, not as a symmetrical whole, but consisting of balls of various diameter, which are fused together into a mass with one another in different degrees, and on which the dentinal tubes, in contact with the germ cavity, are terminated. By reflected light one perceives this stalactite-like condition of the inner surface of the tooth-substance very distinctly, by means of the varied illumination of the globular elevations, and by the shadows which they cast. Here one has evidently to do with a stage of development of the tooth-substance, for the older the tooth is the less striking in general are these conditions, and the more even is the surface of the wall of the germ-cavity. In very old teeth considerable unevennesses again make their appearance; these, however, are not globular but have a cicatrized, distorted appearance. It is best to make the preparation from a tooth, of which the root is not perfectly completed. With such preparations one is readily convinced that the ground substance of the last-formed layer of the tooth-substance appears, at least partly, in the form of balls, which are fused among one another and with the balls of the penultimate layers; and one also perceives that in general their diameter becomes less and less, somewhat in the form of a point, towards the periphery of the tooth-substance. The majority of these balls is pierced through by one or more tubes, crosswise, from within outwards. Very frequently, however, they appear homogeneous, and contain no tubes."

I will only add, from my own observation, that the globular surface is hardly so general as Czermak implies. Often one sees a considerable area that is even and flat, and destitute of globules. The large globules are always traversed with tubes; those not traversed by tubes are always small. The globules, on the germ surface of secondary dentine, are small and tubeless; they are often very minute.

I have found it much easier to obtain specimens than the plan proposed by Czermak, by procuring a tooth of which the fang is half grown, then introducing the point of a penknife into its open extremity, and scraping the inner surface. Small portions may be detached, which exhibit the globules admirably.

Another method of obtaining specimens, which further illustrate the internal surface of the dentine, is the following. In rubbing down a section of a tooth, as the operator approaches the pulp cavity, the last film of dentine frequently bulges into the unresisting cavity, and, instead of grinding up into particles, comes away in a little sheet, a little film of dentine parallel with the pulp-cavity's surface, the innermost layer, and the one last formed. This should be carefully preserved and mounted. On viewing such a specimen by transmitted light, one sees the globules scattered about—some isolated, others more or less confluent; and between them a pale, rather indefinite structure, uniting the whole into a sheet.

Now, in Czermak's specimen one sees only the stalactite-like surface of the pulp cavity, and the prominent inner globules do not appear connected; whereas, in specimens obtained as I have just described, they are seen to form part only of the innermost layer of dentine. Upon close inspection, by transmitted light it is found that the globules are composed of well-formed consistent dentine traversed by patent tubes, the open extremities of which are presented to the eye. The tissue between the globules has a somewhat similar aspect, but the tubes appear shrivelled and collapsed, or are not indicated (see fig. 4). The innermost layer of secondary dentine, viewed under similar circumstances, presents the same general aspect: but the globules are tubeless, and the intermediate tissue appears homogeneous (see fig. 5).

But the most instructive specimens are to be obtained from the very thin cap of dentine found upon the fœtal pulp. The thin edge should be cut off, and examined on the inner surface; it should be moist, and never allowed to get dry. In such specimens the globules are very apparent, but, as Czermak observes, they do not appear superficial but in the substance of the dentine. This he has not explained, but I have observed that, by gradually depressing the focus of the microscope, the first object that meets the eye is the ends of the columnar pulp-cells adherent to the surface of the dentine. As the focus is carried deeper, these appear more or less fused together, and more remotely the dentine assumes a consistent and definite structure. It is here, in the moist specimens, that the focus reaches the globules, and, consequently, there is no superficial stalactite-like bulgings of globules: it is only in dry specimens that that is seen. *Now, if such a specimen be steeped in dilute muriatic acid so as to remove all the earthy materials, the globules instantly vanish, and the dentine, where they were seen, assumes the same aspect as that where they were not seen. No other change is produced.* The existence of the globules, therefore, seems dependent upon the presence of earthy material. This suggested to Czermak the idea that the organic material of dentine is, during the calcifying process, impregnated with earthy salts in globular forms, and that, by a deeper degree of calcific impregnation, the whole tissue is imbued with the hardening element, and the globules are fused. Such a doctrine is capable of explaining all the circumstances of the case; and we have only to imagine an arrest of calcification at the globular stage, over the surface of the pulp as it exists at any one time, to explain all the phenomena of the contour markings.

In teeth which have been allowed to get dry, one would imagine that those portions of dentine which have calcified would retain a consistent form, while the uncalcified animal material would shrivel up: hence the stalactite-like appearance of the pulp-cavity's walls, and hence also the interglobular spaces in a dried tooth. I have shown that, in the innermost layer of dry dentine, the globules are held together by an attenuated tissue, in which the ends of dentinal tubes are indicated. Again, the contour lines, which exhibit no interglobular spaces, but which are continuous with imperfectly calcified globular patches, may be imagined to be themselves dependent on deficient lime impregnation. The integrity of such deficiently-hardened dentine would be seriously interfered with by getting dry; hence, probably, one reason why decalcified dentine so readily tears along these lines.

Now, the idea that the contour markings are produced by an imperfect supply of calcarious material is consistent with other collateral circumstances. Upon that idea one would imagine that other tissues besides dentine, dependent for their maturation on lime impregnation, and the other teeth, would suffer at the same time; that is, believing the effect to be produced by a general vice of nutrition: and such, indeed, is the fact. The enamel almost always suffers at the precise spot where the globular patch abuts upon the surface, rendering it irregular and rocky; and it will constantly be found that these appearances are observable on many teeth of the same individual; not at the same spot on all the teeth, but at places corresponding with the different degrees of development which the various teeth would have attained at one particular period.

Why the dentine should be thus aborted, so to speak, at successive periods of its growth, and why during intermediate intervals it should mature perfectly, are questions which can only be explained by imaginary successive periodic conditions of depressed and healthy nutrition in the individual during the formation of such teeth.

Observations on the Muscular Tissue of the Skin. By JOSEPH LISTER, M.B. Lond. F.R.C.S.

AMONG the abundant new matter contained in those parts of 'Kölliker's Microscopische Anatomie' that are hitherto published, there is perhaps nothing more striking than the announcement that small bundles of unstriped muscle exist in all parts of the dermis that are provided with hairs, connected inferiorly with the hair-follicles, just below the sebaceous glands, and passing up obliquely towards the free surface of the skin.

The effect of the contraction of such little muscles must necessarily be to thrust up the hair-follicles and depress the intermediate portions of skin; in other words, to produce cutis anserina; and thus this condition, previously quite unaccounted for, received at the hands of Professor Kölliker a simple and beautiful explanation.

In March of the present year (1853) I made an attempt to verify this most interesting discovery; and although the somewhat arduous duties of a resident office in University College Hospital prevented me from making the investigation as extensive as I could have wished, yet I found myself able not only to verify, but in some slight degree to add to Kölliker's observations. And as the main fact of the muscularity of the skin had not previously, so far as I am aware, found confirmation in this country, I have been induced to publish my results in the hope that they may prove acceptable to the microscopical anatomist.

Kölliker originally described* these muscles of the skin as flat bundles of unstriped muscular tissue, from 1-120th of an inch to 1-75th of an inch in breadth, of which there appeared to be one or two in connexion with each hair-follicle: it seemed probable to him that they arose from the superficial parts of the corium, and he had clearly seen them passing obliquely downwards to their insertion into the hair-follicles, close behind the sebaceous glands which they embraced. In his 'Handbuch der Gewebelehre,'† published in 1852, he gives in the text exactly the same account of these muscles, except that he no longer expresses any doubt regarding their origin from the superficial parts of the corium. He afterwards states in a note that these muscles had been very recently seen by two observers, Eylandt and Henle, both of whom, however, had found them narrower than he. Eylandt, who named them "arrectores pili," had never seen more than one bundle connected with each hair-follicle, and had failed to detect muscular tissue in the nipple and areola, and in the subcutaneous cellular tissue of the *scrotum*, penis, and perinæum, where Kölliker had described it as existing. Henle had traced the muscles to the most superficial parts of the dermis, where they divided into numerous little bundles 1-3000 of an inch in diameter, which could be followed to immediately beneath the epidermis; he had also seen muscular tissue in the nipple, areola, and the other parts where Kölliker had described it, but, on the other hand, in the opinion of Kölliker, he had gone too far, inasmuch as he described

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* *Vide* Microscopische Anatomie, vol. ii. part i. p. 14.

† *Vide* Handbuch der Gewebelehre des Menschen, p. 82.

bundles of plain muscular tissue as existing on the exterior of the sudoriferous glands and blood-vessels of parts destitute of hairs (such as the palm and sole). These Kolliker is unable to discover, and he believes that Henle has been misled by the use of boiled preparations, in which, as Henle himself states, fine branches of nerves are liable to be mistaken for muscle. Thus it appears that the confirmation furnished by these two observers is by no means a very satisfactory one, and that Henle, the only authority on whom we rest for the fact of the muscles taking origin immediately beneath the epidermis, cannot, in the opinion of Kölliker, be implicitly relied on with reference to this investigation. It appears remarkable that Eylandt should have failed to discover muscular tissue in the scrotum, for the dartos was long since proved to owe its contractility to unstriped muscle. Of the parts in question I have examined only the areola mammæ, which, however, answered well to the description given by Kölliker, who states* that the bundles of muscle are there circularly disposed, forming a delicate layer in the deeper parts of the corium, and encroaching slightly on the subcutaneous cellular tissue. On dissecting a portion of an areola from the subcutaneous tissue towards the surface, I found on reaching the deepest part of the dermis a delicate pale reddish-yellow fasciculus circularly arranged; and a portion of this, teazed out with needles, and treated with acetic acid, presented in a well-marked manner the nuclei of plain muscular tissue. A camera-lucida sketch of a small portion is given on a reduced scale in Pl. VI., fig. 6.

In enumerating the parts where he has met with muscles connected with the hairs, Kölliker does not mention the scalp, probably because the density of the tissue of this part rendered it unfit for investigation by the method in which he prepared his objects, viz., isolating a hair follicle with its sebaceous glands and treating it with acetic acid. Its very firmness and consistence, however, make the scalp better adapted for fine sections than any other part of the skin; and as I succeeded better with sections than by the other method, the scalp has received most of my attention. By compressing a portion between two thin pieces of deal, and cutting off with a sharp razor fine shavings of the wood and scalp together, moderately thin slices may be obtained. Fig. 4 represents a perpendicular section made in this way, and treated with acetic acid; the epithelium has become detached from the free surface *a b*; *b c* is part of one of the muscles near its superficial attach-

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* *Vide* Micr. Anat., vol. ii. part i. p. 14.

ment, and it illustrates pretty well the appearance presented by them under a rather low power. They are distinguished from the tissue around them by their transparent and soft aspect, and by the abundant elongated nuclei scattered through them. Under a higher power the characteristic "rod-shaped" nuclei become fully brought out, and no doubt remains as to the nature of the tissue. A good example of nuclei so magnified, derived from a muscle connected with a hair-follicle of the pubes, is shown in fig. 5. It will be observed in fig. 4, that the muscle has been traced to within a very short distance of the surface, where the nuclei became obscured by other tissues.

But I afterwards found that much better sections could be obtained from dried specimens. A portion of shaved scalp being placed between the two thin slips of deal, a piece of string is tied round them so as to exercise a slight degree of compression; the preparation is now laid aside for about twenty-four hours, when it is found to have dried to an almost horny condition. It then adheres firmly by its lower surface to one of the slips, and thus it can be held securely, while extremely thin and equable sections are cut with great facility in any plane that may be desired. These sections, when moistened with a drop of water and treated with acetic acid, are as well suited for the investigation of the muscular tissue, as if they had not been dried.

Fig. 1 is slightly reduced from a camera lucida sketch* of such a section, made in a plane perpendicular to the surface of the scalp, and at the same time parallel to the sloping hairs. I find that such a plane always contains the muscles in their entire length, the reason of which will appear shortly. In this figure *d* is the corneous, and *e* the mucous layer of the epithelium; *b*, *b*, ... are the hair-follicles with their contained hairs, both have been more or less mutilated by the process of section; the second hair from the right being a short one, its bulb is seen: *c c* . . . . are the sebaceous follicles, also more or less mutilated: a_1 a_2 . . . . a_6 are the muscles, which appear, under this very low power, merely as transparent streaks, and require a higher power to make out their tissue. The muscles are seen to arise in all cases from the most superficial part of the corium, and to pass down obliquely to their insertions into the hair follicles immediately below the sebaceous glands. It will be remarked that the muscles are here all on the same side of the respective hair-

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* In all the sketches from which the figures that illustrate this paper have been taken, I have used the camera lucida, which instrument has the great advantage of ensuring correctness of proportions.

follicles, viz. on that side towards which the hair slopes: and such I found in the examination of a large number of sections to be always the case. This is an interesting fact, as such an arrangement of the muscles is exactly that which is best adapted for erecting as well as protruding the hairs, which must be drawn by their contraction nearer to the perpendicular direction. That this erection as well as protrusion of the hairs does occur, I have proved by artificially exciting the state of cutis anserina upon my own arm and leg. Tickling a neighbouring part will often induce horripilation, and if the eye is kept on an individual hair at this time, it is seen to rise quickly as the skin becomes rough, and to fall again as the horripilation subsides. I have never seen more than one muscle to each hair-follicle in the scalp; and in order that a single muscle may by its contraction simply erect a hair, it must be placed in a plane perpendicular to the surface of the skin and parallel to the hair; this explains the fact before alluded to, that a section made in such a plane is sure to contain the muscles in their entire length if at all, while sections in other planes cut across either the muscles or the hairs.

Fig. 2 represents the superficial attachments of the two muscles a_1 *and* a_2 of fig. 1; *a* being the upper end of a_1, and *b* that of a_2; *c* is the corneous, and *d* the mucous layer of the epidermis; the intervening tissue between the muscles was omitted in the sketch to save time. *b* furnishes a good example of the subdivision of a muscle into secondary bundles near the surface, as observed by Henle, while in *a* the subdivision, if it has occurred at all, is certainly not carried so far: the muscle *b c* in fig. 4 seems not to have undergone any subdivision: in some cases a simple bifurcation of a muscle near the surface is all that is seen: hence the splitting up of the muscles into smaller bundles near their upper attachment appears not to be a constant thing, and when it does occur exists to a very variable degree in different muscles. Want of room in the plate has rendered necessary so great a reduction of the scale* from the original drawing, as barely to allow the nuclei of the muscles to be perceived; by looking closely, however, it may be seen that at *e* and *f* nuclei exist immediately under the epithelium, and before introducing them into the sketch, I ascertained, by a higher power, that they were really of the same character as those in other parts of the muscles. At *g* it was impossible to trace the nuclei so far; if any existed here, they were obscured by

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* Figs. 2, 3, and 4 have all been reduced one-half from the original sketches.

the fibrous tissue of the scalp, which adheres to the muscles throughout their whole length, but appears to form special sheaths for the bundles of origin at the surface, and these sheaths interfere considerably with the examination of the muscular tissue enclosed by them. In some cases, however, they seem to be prolonged beyond the point to which the muscular tissue reaches, acting as tendons of attachment, and this may perhaps be the case at *g*: I have seen one striking instance of this mode of attachment, where a muscle having divided into two portions at some depth below the surface, a pretty long band extended like a cord to the surface from one of the divisions, and acetic acid having been added, nothing whatever but yellow elastic fibres could be seen in this band (the white fibres had been of course gelatinised). As a general rule, however, the muscular tissue extends to within a very short distance of the epithelium, and often, as above stated, can be detected immediately beneath it, as Henle has represented.

In fig. 3 is shown the connexion of the muscle a_1, of fig. 1, with its hair-follicle; so that were the muscle *a* of fig. 2 continued far enough downward, it would join with *a* of fig. 3. The hair and its follicle are seen cut across very obliquely: *b* is the hair, tilted somewhat out of its natural position in the inner root-sheath *c; d* is the outer root-sheath (corresponding to the mucous-layer of the epidermis), whose outer cells are perpendicular to the hair-follicle*; e* is the "structureless layer" of the hair-follicle*; f* is the circular layer of Kölliker; *g* the external longitudinal layer with which the muscle is seen to become blended. Several elongated nuclei appeared at g_1; whether these are derived from the muscle, which is evidently inserted a good deal into the part of the follicle that is hidden from view, or whether they are only the elongated nuclei that occur in all parts of the longitudinal layer of the follicle, is doubtful: their well-marked elongated character inclined me rather to the former opinion; *h* is a part of one of the sebaceous follicles, which appears to have no special connexion with the muscle that simply passes close by it without embracing it, as Kölliker implies, or sending any muscular expansion over it; and the same occurs in all cases, so far as I have seen; *i* is a portion of the fibrous tissue of the dermis, showing its connexion with the surface of the muscle.

Kölliker's description of the muscles of the skin (see p. 263) does not quite accord with what I have seen in the scalp, either as regards their shape or size. The muscles in this part had not, in sections parallel to their course, the appearance of flatness; and by cutting slices in the way above indicated, at right angles to their known direction, their transverse sections were readily seen, and proved to be often quite circular, sometimes somewhat elliptical or polygonal, showing their form to be that of more or less rounded bundles. Their average diameter is, according to my experience, 1-200th of an inch, which is less than half the average of Kölliker's measurements, but this discrepancy is probably due to difference of situation in the parts observed, Kölliker not having examined the scalp: for one muscle which I sketched from the pubes was very nearly 1-100th of an inch in diameter.

With regard to the statement of Henle, that muscular tissue exists in parts destitute of hairs, I have searched with diligence many good sections of both the palm and the sole, without having been able to discover any evidence of it on the exterior of either the sudoriferous glands or blood-vessels of these parts. In a section treated with acetic acid, the elongated nuclei of the internal coat of a small blood-vessel sometimes give it an appearance that might at first sight be mistaken for that of unstriped muscle; but this is an error easily avoided by care, and I cannot but agree with Kölliker in thinking that, in some way or other, his boiled preparations have led Henle into error.

In order to verify Kölliker's statement* that no unstriped muscle exists in connexion with the vibrissæ of mammalia, I examined the feelers of a cat. These large hairs extend far down into the tissues beneath the skin, and have a more complex muscular apparatus than the small hairs of the human skin. Bundles of muscles extend from the lower part of the gigantic hair-follicle obliquely upwards to the inferior aspect of the skin, and, in addition to these, there is muscle surrounding the large nerve that enters the base of each hair-follicle. These muscles were all of the striped kind, but extremely soft and extensile, and among the fibres were a number of very elongated nuclei, but I saw no distinct evidence of the admixture of unstriped muscle.

In conclusion, I may state that this investigation has proved to me the general correctness of Kölliker's original observations, and also of the results of Henle's further inquiry, except in the case of the alleged muscularity of parts destitute of hairs; and I shall be happy if the little additional matter communicated in this paper shall be found to bear as well the scrutiny of others.

University College Hospital, June 1st, 1853.

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* *Vide* Micr. Anat., vol. ii. part i. p. 15.

TRANSLATIONS.

Remarks on the STRUCTURE *and* FUNCTION *of the* RETINA. By H. MÜLLER. From the Verhand. der Physical. Medicin. Gesellschaft in Wurzburg. B. III., H. III., p. 336. 1852.

THE view respecting the physiological function of the various layers of the *retina* arrived at by Professor Kölliker, from the investigation of the human eye, and which he has detailed in a previous paper in these Transactions, I have, also, been led to adopt in the most essential points, from continued researches respecting that membrane.

On the one hand, the difficulty, and almost the impossibility, of maintaining that the expansion of the optic nerve is the perceptive element for objective light becomes continually more and more obvious; and, on the other, the mosaic-like contrivance for the reception of impressions separated by spaces, which was formerly generally assumed as a postulate, although in vain sought for, in consequence of the altered view respecting the structure of the retina, appears now to be admitted; particularly since it has been shown that the radial fibres are continuous *externally* in "cones" and "rods," but are internally in the closest contact with the expansion of the optic nerve, and probably in part connected with it. The circumstance, that such a radial arrangement of the retinal elements occurs in all the vertebrate classes (*vid.* Zeitsch. f. wiss. Zoologie, III., p. 234), notwithstanding all the divers variations which otherwise exist in the condition of the individual layers, confers an important significance upon this arrangement. But in favour of the notion, that it is the radially disposed elements, and not the horizontal fibres of the optic nerve, which first perceive the objective light, I find, besides the points adduced by Professor Kölliker, a weighty argument in the peculiar *structure of the retina in the Cephalopoda*, whose much developed eyes, of all the Invertebrata, come nearest to those of the vertebrate class.

In the *Cephalopoda* the innermost layer of the *retina* consists of elongated, slender, transparent cylinders, which are, in many respects, similar to the "rods" of the vertebrata; and like them densely crowded together, are disposed in the direction of the radius of the whole eye. Behind these is a layer of pigment, which is penetrated by fusiform filamentary prolongations of each cylinder. Whence is effected the connexion with the outer layers of the *retina*, of which the last or outermost is the horizontal expansion of the fibres of the optic nerve. Thus the arrangement of the elements is one, pretty nearly the opposite of that which obtains in the Vertebrata.

In this case, at all events, it is evident that the light must penetrate the innermost bacillar layer, in order to reach the other elements of the *retina*.

At the same time it is hardly conceivable that the light should act directly upon the fibres of the optic nerve, which lie far behind the pigment, since it is certain that no image can be there formed.

The perception of the latter must rather, in the first instance, proceed only from the radially-disposed elements, which alone are opposed to the light.

This function must be assigned either to the continuations of the innermost "rod-like" cylinders, corresponding in some degree to the "cones" of the Vertebrata, and which project into the pigmentary layer, whilst the cylinders themselves would serve for the isolated conduction of the impression, or, it may be, the cylinders themselves are destined for the perception, and all that lies behind them, merely for the conduction.

Thus the arrangement agrees very much with the notion, which, *à priori*, appears to be the most plausible; that most internally there is a mosaic layer for the reception of light, behind that a pigment for the absorption of the light which has been admitted, traversed by radial filaments, which communicate the impression to the horizontal fibres of the optic nerve.

Now, since in these eyes there can hardly be any doubt that the radial elements serve for the perception of the objective light, whilst the horizontal are simply subservient to the conduction of the impression, a similar condition becomes the more probable, also, in the Vertebrata.

The notion, that the radial elements serve for the reception of light, involves a change in the bases upon which are founded the considerations respecting the relations of the *smallest distinguishable retinal images to the elementary constituents of that organ.*

The difficulty presented in the supposition that very small portions of the same fibre, taken longitudinally, were necessarily to be regarded as possessing different perceptive properties, is removed, and, what must now be admitted, that a fibril of the optic nerve merely *conducts* different impressions, appears at all events less objectionable. The comparison of the mosaic portion of the retina, with the calculated proportions of the smallest images, would at the same time afford an indirect argument for or against the above view, on which account I will add a few statements to those already adduced by Professor Kölliker.

It is easily shown by experiments, as well as from the comparison of various statements (vid. Volkmann, 'Handw.' d. Phys. Art. 'Sehen.,' p. 331), that for a single impression, the calculated image may be almost infinitely small, if only the illumination be sufficiently powerful; for instance, a small hole in a black lamp-shade, or an object glittering in the sun. The dimensions, thus obtained by calculation, are so many times less than the transverse diameter of the elementary parts of the retina in question, that unless a very incomplete union of the luminous rays in the eye be assumed, it must be concluded that it is only requisite that one of these elementary parts should be acted upon with sufficient intensity, only in a small point, in order to communicate the impression of light.

On the other hand, the possibility of distinguishing the smallest distance, shown by Volkmann to exist, might depend upon this, whether several luminous pencils are incident upon *one* or *several* elementary parts. It is necessary, however, previously to consider the site of the most distinct vision, because as we proceed towards the lateral portions of the *retina*, both the optical and the anatomical conditions become more complex.

Volkmann recognized the duplicity of the two filaments of a spider's web, at a calculated distance of the retinal images of 0·0044‴, and for a friend who had the most acute vision, of 0·0025‴.

Valentin (Physiologie, II. 3, Abth. p. 259) distinguished the distance of two micrometer lines, with a distance of 0·0022‴; and in a second case, with one of 0·0014‴, on the retina.

As regards my own eyes, the results derived from the observation of a whole series of micrometer lines, or of the lines in a steel engraving, under favourable conditions of illumination, varied between 0·0025‴ and 0·003‴.

On account of the difference, which, moreover, occurs in the perception of lines and points, I thought it would be necessary to consider the latter also, but I found that the differences are not very important. The distance from the eye at which the lined and pointed spaces of a steel engraving can no longer be recognized in their separate elements, but appear uniform, was pretty nearly equal, with equal interspaces between the latter.

Two lines, made with a fine needle-point, with an interspace of 0·2‴, could be recognized as double, at a distance of about 3 feet, by transmitted light. If the number employed by Volckman (l. c. p. 289 and 331), viz. 6·23‴, be applied as the distance of the focus from the axial point of the *retina*, the distance between the retinal images would be 0·0022‴; in the instance of several holes, 1-7‴ apart, seen at a distance of 20 inches, the distance between the retinal images is 0·0037‴; in that of a wire-sieve, 44 of the openings in which, taken longitudinally, go to an inch, at a distance of about 3 feet, at which they were still very distinctly separable, the distance of the retinal image is : 0·0039‴; and at 4 feet : 0·0027‴.

If these calculations be based upon the proportions of the eye, given by Listing (Handwörterb. der Phys. IV. p. 496), it is true that somewhat larger numbers are afforded; for instance, instead of 0·0039‴ : 0·0042‴. This difference, however, particularly in greater distances, is of inconsiderable moment. On the other hand, in peculiarly acute eyes and under highly favourable conditions, somewhat smaller values are presented.

Now, if the above numbers are compared with the diameter of the larger elements in the bacillar layer, viz., the cones (bulbs), which Kölliker found to measure 0·0025 — 0·0045‴, but in the "yellow spot," not more than 0·002 : 0 0024‴, only the one statement of Valentine is decidedly less, all the others equal, or a little (but within moderate limits) larger than the cones of the "yellow spot." The diameter of the "rods," on the other hand, is many times exceeded.

It would be impossible in any case to arrive at an absolute correspondence, and particularly do the greater values of the distances between the images admit of an easy explanation. In general the intervals of several perceptible points must be somewhat greater, because the arrangement of the points will not readily be exactly conformable to the arrangement of the parts of the retina, and consequently the image of a point sometimes falls between, or in other words, upon two retinal elements; sometimes a single element will be touched by the images of two points.

In greater measurements this must take place, for the reason that the focus never represents an absolute point, but small circles of diffraction, and the larger these are in the eye, so much the less will it be in a condition, as Volkmann has stated, to appreciate the smallest distances.

By the circumstance that the image of a point touches several elements, the phenomena of irradiation may be explained, within certain limits. The distinct perception, also, of two points, the distance between the image of which is not quite equal to the diameter of one of the retinal elements, might, according to the above view, be possible in a very acute eye, because the image in a particular position might nevertheless touch two different elements.

Thus, the facts hitherto ascertained, appear, in general, not to be opposed to the notion that the perception of the smallest distances depends upon the circumstance that different elements of the bacillar layer are touched by the image, and this correspondence again, equally favours the view that, that layer is the apparatus for the reception of the luminous impressions.

Physiological Remarks on the Daphnidæ. By Dr. W. Zenker. Müller's Archiv, 1851, p. 112, Pl. III.

An organ, occurring in the Daphnidæ, about which a good deal has been said, is the curious "black spot" in the head, in front of the eye. It is seldom entirely wanting, as in *Daphnia brachiata*, *D. cornuta*, M. E. (*Eunica longirostris*, Koch, *Lynceus longirostris*, Müller, *Bosmina longirostris*, Baird), and *Polyphemus;* is much elongated in *D. sima*, and is so large in the genus *Lynceus*, Müll., that it was considered by O. F. Müller as a second eye (Entomostraca, 1792, p. 67). Subsequently, it has been looked upon as an auditory organ (Schödler, üb. *Acanthocercus rigidus*, Wiegm. Arch., 1846, bd. 1). It consists invariably of a minutely granular, black substance, without a vestige of crystalline lenses or similar organization, and is situated immediately upon the brain, or, at all events, is only separated from it by a very short nerve. It occurs not only in the Daphnoida, including the Lynceidæ, Baird, but Liévin has also noticed it in *Hedessa Sieboldii*, a new monoculous Phyllopod. (Branchiopoda der Danziger Gegend. 1848, p. 11, Pl. II., fig. 10.)

In the full grown animal the function of this organ is not readily made out with certainty, whilst, on the other hand, it is during the embryonic development of the animalcules within the mother that the nature of this black spot is most clearly evident. It is known that in the embryo of the Daphnidæ there are at first two eye-spots on both sides of the head, which unite into a spherical mass not long before birth. At a time when the eye-spots are only faintly indicated, and of a brown colour, there is evident, seated on the brain, below and in front, a solitary sharply defined deep black speck, in which may at once be recognized the black speck of the full-grown

Daphnidæ. It is necessarily formed long before the eyes, and is thus the first developed organ of sense.

If now it be asked, what organ in the allied Crustaceans, and especially in the *Phyllopoda*, corresponds with this, it will be found in the tripartite azygous eye, which occurs so extensively under various conditions throughout the Crustaceans. It occurs as the only visual organ in *Cypris*, *Cyclops*, &c.; in conjunction with the aggregated eyes in *Artemia*, *Argulus*, &c.; but it appears regularly in all the Branchiopoda and Siphonostomata as the *earliest* visual organ. It is always placed immediately on the brain, thus also showing its correspondence with the black spot of the Daphnidæ.

Another question is, whether this spot, the nature of which we have developed in agreement with Siebold's supposition (Vergleich. Anat., 1848, p. 445), actually fulfils the function of an eye during the period of embryonic life, or whether, independently of any such utility, it is formed merely in accordance with the law of development of the Branchiopoda. As the shell of the Daphnidæ is transparent, a certain impression of light may be conveyed to the embryos; but as the embryo, so long as it does not possess freedom of motion, has no need to distinguish objects, so there is no necessity for any refractive body. The other Branchiopoda must, however, before they have other eyes, move about freely in the water, and are, therefore, provided with refractive bodies. In these the pigment of the eye is for the most part red; in *D. Pulex*, on the other hand, it is brownish red, and in *Sida crystallina*, black.

It therefore does not appear to be essential what form this black spot may occasionally assume in the full-grown animal. In the embryos it precisely resembles the form of the eye of *Cyclops*. In the young *D. sima* it is round, also for some time after birth; at a later period it becomes elongated. Unfortunately, I have not observed in those Daphnidæ, in which, when fully grown, the spot is wanting, whether they possess one in the embryo state.

There is no doubt that an isolated Daphnia will of itself produce new generations, and that these again will bring forth others without impregnation, and so on for many times, and probably without limit. This mode of propagation, which occurs in some Insects, is one distinct from all others, and cannot be identified either with gemmation or with an alternation of generations. Gemmation does not take place in the ovary [why not?], and an alternation of generations does not take place in cases where the same female individual can produce young, being first unimpregnated and then impregnated. Moreover, after impregnation there is absolutely no difference in the development of the ovum, except that the impregnated ovum comes to be enveloped with a firm, corneous, saddle-shaped shell (the so-called Ephippium). In the Phyllopoda this distinction even appears to fail, as Liévin, who had noticed both the male and female in *Hedessa Sieboldii*, makes no mention of ephippian ova.

The males of the Daphnidæ, it is true, are found all the summer through; but very seldom, and, as it would seem, not of every species. On the other hand, towards winter they become much more numerous, so that the winter is the fittest season for the study of their sexual relations. All the species of Daphnidæ succeed each other in the production of male individuals. The males of most of the true *Daphniæ* are met with in October, whilst those of *Lynceus* abound more towards Christmas. In consequence of impregnation a large number of ephippia are produced, in which the ova are probably more protected against decomposition or untimely development than from cold. The same succession prevails with regard to the ephippia, in the different species, as in the appearance of the males. It would thus fairly appear that the ephippia are a product of impregnation. Direct experiments, however, have not as yet been instituted, to determine whether impregnation precedes each ephippium, and each impregnation is followed by an ephippium. At last, as the temperature lessens, scarcely any but males are produced, and the animal disappears from the water; at the bottom of which, however, in the submerged ephippia, provision is made for the revival of future generations.

The males are distinguished, even externally, from the females by the different formation of certain members, especially of the antennæ, the first pair of legs, and the tail; for the most part, also, in the size and width of the body, the males being smaller, and wanting the uterine cavity under the back. Internally the testis may be distinctly recognized as a single organ, corresponding in form and position with the ovary. *Evadne Nordmanni* is the only species in which, up to the present time, the existence of the testis has been indicated with certainty by Liévin.

The simplest form of this gland is presented in *Sida crystallina*. If the creature be placed on the side, the testis lies immediately upon the intestine, and is at once seen when the focus of the microscope is a little raised. It is parallel with the intestine, about half as broad, and extends from the last to the first pair of feet, being curved at the extremity, which looks forwards. The opening of the gland is situated in the tail, on the abdominal or pedal aspect. This opening varies but little in its position throughout the Daphnidæ. The analogy between the testes and ovary is most evident in *Sida*, and they might readily be confounded, were not their contents very different. Whilst in the female, the ova, with germinal vesicle, and surrounded with a vitelline substance, are evident, the contents of the testes, which exhibit in all respects similar forms, consist of the well-known nucleated, immotile, spermatozoid cells, which are peculiar to some Crustaceans. They are formed in the curved cæcal extremity of the testes, from cells, the structure of which, on account of their minuteness, cannot be further made out. The spermatic cell, however, itself, is only about 0.001′′ large.

In this species the male differs externally but little from the female. It is somewhat smaller (males 1.0′′′, females 1.2′′′). The antennæ are two-jointed, and the basal joint runs out into a strong lateral spine, supporting a serrated seta, and pushing the second joint to the side. The latter supports the antennal seta, minutely described by Schödler.

As the genus *Daphnia* stands nearest to *Sida* in the simplicity of the intestinal canal, so does it also in the simple construction of the testes and ovary. The difference between the two genera is exhibited more in the arrangement of the muscles and the form of the joints than in the viscera. Thus the testis in *D. Pulex* is exactly as in *Sida crystallina.* The antennæ, also, are formed in an analogous way, except that they are jointed. The beak of the male projects a little more than that of the female. The caudal portion of the body supports, besides the usual caudal setæ, a motile papilla, in the same situation as that in which, in the female, the teeth for the retention of the ova are placed. This papilla, which is peculiar to the male of *Daphnia Pulex*, is covered with scales, and resembles in many respects the points at the margin of the shells, within which it is frequently placed, in order to draw the body of the animal more firmly between the shells. Neither Jurine nor Strauss figure this papilla, nor is it mentioned by Liévin. The male is considerably smaller than the female. I have also had an opportunity of observing the very interesting formation of the sexual organs in the genus *Lynceus*. It differs from that which obtains in *Daphnia* principally in the curved or twisted intestine; and as in the previous case, so also in this, does the testis present a corresponding relation. It is curved backwards once, parallel with the intestine on both sides. Here again, also, is shown an analogy with the ovary, which itself runs straight between the first and fourth pair of feet, but the excretory duct of which follows the curvature of the intestine. At its cæcal extremity the testis is again curved backwards and inwards; but it is not there only that its secretion is formed; this is produced, also, in certain cæcal pouches, which branch out from the testis in a backward and upward direction. Both testes open in the tail, at the point above indicated; their vasa deferentia continue separate to the last.

These points are seen most simply in *L. macrurus*, which differs from the female only in the form of the antennæ; possessing, however, the same broad form and long tail as the latter.

In *L. lamellatus* the testis between the curvature and the opening is furnished on each side with a large vesicle, which may be termed a vesica copulativa, and from which the secretion may be expressed. The above, with the addition of *L. sphæricus*, are the only Daphnidæ with the males of which we are acquainted. The time to look for the rest is the winter. I suppose, from the similarity with the Phyllopoda, which has already been so frequently adverted to, that the males of that family also will be found principally in the winter.

[In *Chirocephalus diaphanus*, Prev., *Branchipus stagnalis*, M.E., the number of males is very considerable, and pretty nearly equal to that of the females at all times of the year. This fact seems to afford a curious confirmation to Dr. Zenker's opinion, that the chief object of male impregnation is the production of ephippian or winter ova. In the case of *Chirocephalus* this provision becomes repeatedly necessary during the year, and not towards winter only; for it is a remarkable fact, on Blackheath, at all events, that the *Chirocephalus* is never found in any of the several ponds on the heath, except in those which dry up completely, at least once, but in most years several times, or for the whole summer continuously. The ponds inhabited by the *Chirocephalus*, in fact, are merely pools formed by the drainage from the roads. Now it is manifest, under these circumstances, that, were not provision made by the formation of winter ova, or ova having a thick double coat for the revival of the race after the drying up of their habitation, it would become extinct. We accordingly find that such provision is made in the numerous males at all times present. The extraordinary power possessed by the ova of *Chirocephalus* of resistance to the effects of desiccation is very remarkable, as is also the readiness and rapidity with which they are developed when again subjected to the influence of water. If the basin of a small pool which has been dry, and even dusty, for months, becomes filled after a few days' rain, the water will be found swarming with myriads of *Chirocephali* in about ten days or a fortnight. Or if a piece of the dried bottom of such a pool be placed in a pailful of water, numerous *Chirocephali* will be hatched from it in the same time. The reason for this curious arrangement with respect to the *Chirocephali* is obvious enough. These delicate creatures, themselves vegetable feeders, are the prey of innumerable enemies; among the chief of which are the larvæ of *Dytiscus*, and of dragon flies, &c. In ponds which never dry up, these voracious enemies have time and opportunity to destroy the whole race of *Chirocephali;* but in the favourite haunts of the latter, their enemies not being able to survive the drying up of the water, are cleared off on each such occasion; and the *Chirocephali*, being rapidly hatched, have, as a race, time to propagate and deposit their posterity in safety for another resurrection.—Ed.]

On the Identity of a Colouring Matter present in several Animals with the CHLOROPHYLL *of* PLANTS. By M. MAX SCHULTZE, *of Greifswald.* Comptes-rendus, Tome xxxiv. pp. 683. May 1852.

THE author enumerates several animals of a green colour, which are common in ditches and marshes—such as *Hydra viridis*, several green *Turbellariæ*, *Vortex viridis*, *Mesostomum viridatum*, and *Derostomum cæcum;* and also several green Infusoria, such as *Stentor polymorphus*, *Ophrydium versatile*, *Bursaria vernalis*, &c. The colour in these animals is afforded by minute green globules, about 0.016 inch in diameter, which are situated under the integument in the parenchyma of the animals. They are perfectly spherical, and exhibit within the green substance an extremely minute, colourless, and homogeneous nucleus; or they may consist of several minute green globules, grouped together in a mulberry form; in this latter case they arise from the division of a homogeneous vesicle.

This green colouring substance is not altered by dilute acids or alkaline solutions; by which it is distinguished from the green colouring matter of several Algæ, which according to Nägeli is changed into a yellow orange or red by the same re-agents. Concentrated sulphuric and muriatic acids dissolve the colouring matter; the solution is of a beautiful green or bluish green colour, unchanged by the action of heat; it is also dissolved by a concentrated solution of potass—by ammonia, alcohol, and æther, the colour precisely resembling that of a solution of chlorophyll.

Its development, also, is influenced in the same way as that of Vegetable chlorophyll by light; but animals containing it do not evolve oxygen, and the author thence concludes that the evolution of that gas is not solely dependent upon the chlorophyll in plants.

In *Vortex viridis*, the minute green globules, owing to their mutual compression, assume an hexagonal form—the green compartments thus formed are separated by an interstitial colourless substance. The existence of a colourless membrane around each green vesicle may thence be deduced. This fact is further demonstrated in vesicles, the green matter of which only partially fills the globular cavity.

With respect to the chemical composition of the membrane and of the nucleus of the vesicles in *Vortex viridis*, the results of the author's researches are limited to the following facts,—the solutions of potass, and of ammonia, and sulphuric acid, after the extraction of the colouring matter, cause the membrane to swell out, in which the nucleus can no longer be recognised. The membrane becomes pale and finally disappears entirely, but especially so after long boiling. Acetic and chromic acids and alcohol do not affect the membrane and the nucleus. By solution of iodine the vesicle is coloured brown, the nucleus becomes more distinct, but its colour is unaltered. It cannot consequently be assimilated to the nucleus of the vegetable chlorophyll vesicle, which most frequently consists of *amylum*.

Observations on the Circulation of the Blood in the ARACHNIDA. By M. EMILE BLANCHARD. Comptes-rendus, Tome xxxiv. pp. 402.

BY the injection of the blood-vessels of a large *Mygale* (*M. Blondii*) M. Blanchard was successful in tracing and dissecting all the arteries distributed to the various organs, to their ultimate ramifications, which he describes. The venous system is much less perfect, consisting for the most part of canals without walls admitting of their being isolated by dissection—except in certain situations. He concludes in remarking that the circulation of the blood in the Arachnida is effected by means of an arterial system of the most complete kind, and of a venous system very imperfect it must be confessed compared with that of the Vertebrata, but which nevertheless, owing to the great regularity of its course and its limits, which are so well circumscribed, exhibits a degree of perfection not, hitherto, well established.

REVIEWS.

THE SEA-SIDE BOOK; BEING AN INTRODUCTION TO THE NATURAL HISTORY OF THE BRITISH COASTS. By W. H. HARVEY, M.D., M.R.I.A., &c. London. Van Voorst (sec. ed.), 1849, pp. 264, 12mo.

A NOTICE of this work, published in 1849, may seem somewhat out of date in 1853; but, in the first place, even had not the brief existence of this Journal necessarily prevented an earlier reference to it, we do not think that the mere lapse of time since its appearance should deter us from recommending to our readers so pleasant and instructive a companion, especially at this season of the year, when so many of them, as we hope, will be preparing for a sea-side ramble, and about to enjoy, for health or relaxation, the vivifying breezes of the ocean. Neither is a notice of the book out of place in this Journal, seeing that Dr. Harvey has devoted a chapter, and a very interesting one, specially to the "Microscopic Wonders of the Sea."*

The "sea!" that magic word to the wearied denizen of towns, whose only glimpse of nature, perhaps for eleven months in the year, is obtained in a dusty, suburban road, or London square;—with what varied tastes are its refreshing breezes sought, and in what different senses enjoyed! but to none, perhaps, does it offer greater attraction than to those who delight in inquiring into the microscopic world of nature. Nowhere in her wide domain will be found so many, and such diverse objects of microscopic research as are afforded in the sea, and on its rocky or sandy shores. On rock or sand, bare, or covered with the russet garb of Nereis, the diligent seeker will never fail to find subjects for contemplation, endless interest, and instructive study. The pages of the Transactions of the Microscopical Society alone, bear witness to the numerous objects of research afforded in the tiny denizens of the sea; and to the attentive microscopic study of these

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* The high estimation in which Dr. Harvey's book is justly held, may be deduced from the fact that an influential Society has thought it expedient (whether properly or otherwise is another question) to publish a very close imitation of it, under the name of the 'Book for the Sea-side;' with reference to which all we would observe is, that the *external* imitation has been much more successfully executed than the *internal*. Our readers will observe that the 'Book for the Sea-side' is not the 'Sea-side Book' that we recommend to them.

creatures are we greatly indebted for many important advances which have of late been made in physiological and anatomical knowledge. To these creatures, as well as to many others, Professor Harvey's little work will afford a pleasant introduction. All, of course, do not take interest in the same subject; and here we naturally address ourselves only to those whose predilections may incline them to investigate the habits and structure of the minutest works of Nature, with which the shore will so abundantly supply them, or with which they may supply themselves, by the aid of very simple appliances.

In his fourth chapter, Professor Harvey, in discoursing of the "Zoology of the rocky sea-shore," says—"In the vegetation of the sea nature has provided both shelter and food for an infinitude of animals. . . . . Troop after troop of animals, one more highly organized than another, either derives its nourishment from the sea-weed itself, or uses the submarine forest as a hunting-ground, where it fulfils the appointed course of its busy life. Adhering to the roots of sea-weeds we find the scarcely organized, but obviously animated, sponge. . . . . To the stems and leaves adhere multitudes of incrusting animals, some of which, till we examine them somewhat closely, and watch their animal motions and propensities with some care, seem to consist merely of masses of jelly; while others display in their outward forms the branching appearance of mosses; every branch clothed with scales, and crowned, when the animal is in vigour, with starry flowers."

The latter class, or the so-termed zoophytes, will almost everywhere afford the most varied and interesting objects for microscopic observation. For an account of the different species to be met with on the British coasts, the best works of reference are Dr. Johnston's 'British Zoophytes,' or for those who may be content with a less extensive work—a little book, of which we have given a notice in a previous number—Dr. Landsborough's 'Popular British Zoophytes.'* Some of these creatures will be found adhering to the side of almost every rock-pool left by the retiring tide, or adhering to the roots or leaves of numerous *fuci*. Many appear to prefer old shells or loose pebbles, and some of the most beautiful and interesting forms will be found in such situations; in ap-

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* We should here, also, have referred to Mr. Gosse's recent work, "A Naturalist's Rambles on the Devonshire Coast," but it has not come into our hands until these sheets are passing through the press. We reserve a notice of this highly interesting book —particularly to the Microscopist—for our next number, in the meanwhi strongly recommending it to our readers.

pearance to the naked eye — nothing but a scurfy scale. These rocky or tidal pools should be often and diligently searched; for the number and variety of minute animal and vegetable forms to be found within the narrow precincts of one of these Lilliputian lakes is astonishing. "Nothing," as Dr. Harvey says, "can exceed the beauty of a clear rock-pool seen under strong sunlight, and through a calm surface, tenanted by its various animated tribes, all fulfilling the duties allotted to their several kinds." In them will be found, adhering to the weeds, or to the rocks themselves, an infinitude of species of Zoophytes, sponges, minute crustaceans, and the elegant forms of different *Lucernariæ*, together with many of the smaller and most delicate *fuci*. Leaving the rocks for the more sandy parts of the shore, we shall find "along the margin of the tide, as well as at different levels of the beach, and in the crevices of the rock-pools, small patches of drifted sand and shells, the examination of which will often afford the patient explorer a rich treat."—"Careful examination with a lens will generally detect a multitude of minute shells, some of very strange shapes, and others structures of great elegance." These are the various species of *Foraminifera*, with many of which, in the dead state, most of our readers are probably well acquainted; few, however, have studied them in a living condition, and this study we would recommend as one of great interest and importance. The same drift-sand will often be found to contain a "wonderful variety of minute spiral univalve shells," "though these are scarcely of so small a size as to come within the list of genuine microscopic objects." "Others may be obtained by the gatherers of sea-weeds with little trouble, if they will only preserve the sediment that collects in the water in which the sea-weeds are washed." "When the sea-weeds are plunged into fresh water, these minute molluscs (*Rissoœ*) are quickly killed, and fall to the bottom, and may then be secured by simply straining the water through a piece of canvas. Many other minute and curious animals, and sometimes *Diatomaceæ*, may be collected in a similar way."

Having thus surveyed the rocks, and sands, and weeds of the shore above low-water mark—if we launch upon the deep itself, a similar abundance of minute and interesting forms is still presented to us. A small muslin bag, the mouth of which is kept open by a wire-ring about 4 inches in diameter —towed slowly behind a boat, on a calm and bright day in any sheltered bay or inlet—will be found to gather multitudes of creatures of the most beautiful forms, and occasionally most brilliant colours creatures whose crystalline substance affords to our wondering gaze a ready insight into many things connected with the structure of the lower animals, which will in vain be sought elsewhere. In this way are collected the numerous species of minute *naked-eyed Medusæ*, so well described and graphically figured in Professor Ed. Forbes' work,* cited below, and which should accompany every microscopic observer to the sea-side. Nothing can be conceived more elegant and graceful than the motions of these minute crystalline bodies in a glass of water. Some as brilliant as diamonds with tiny emeralds set round the edge; others like the beautiful *Turris neglecta*, resembling rubies encased in crystal—rising and sinking through the clear water with the most easy and elegant movements. In the dark, also, most of these little gems will be seen to be furnished with a row of luminous spots around the edge of the disc, at the base of the tentacles, and it is to them, in great measure, that the luminosity of the sea is owing. On almost every part of the coast, besides these forms and the allied *Beroes*, the towing-net will frequently gather innumerable specimens of a creature resembling a slender spicula of glass, about an inch in length, but which is so slender and so transparent as to be almost invisible except in a particular direction of the light—this is the *Sagitta bipunctata*, and its simple structure affords an excellent subject of microscopic research. When fishing for objects of this kind, it is best to have in the boat a large *white* basin half filled with sea-water, and into this the towing-net is to be inverted and gently shaken every now and then. In this way the delicate creatures it contains will come out of it without injury, and though themselves, perhaps, at first wholly invisible, their shadows will be seen with great distinctness against the white bottom of the basin, and thus many forms which might otherwise altogether escape observation, be rendered evident.

The microscopic wonders of the sea, however, are still far from exhausted; it presents as many, if not more, curiosities at the bottom, where its depths are never opened to view, than at the surface. The best and most convenient mode of obtaining these, is by the use of an instrument, with which all, perhaps, are acquainted in one shape or another, viz., the *dredge;* but the naturalist's dredge is not a stone dredge, or a mud dredge, or an oyster dredge, or in fact anything but what it is, the "naturalist's dredge." An instrument of this kind is figured and described by Dr. Harvey; but its construction is very simple, and may be effected, if need be, by almost any

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* Prof. E. Forbes. British Naked-eyed Medusæ. A Monograph. Published by the Ray Society. 1847.

country blacksmith. The essential qualities of a dredge of this kind are, a small and convenient size, with sufficient weight to ensure its sinking to, and keeping at, the bottom, even when at a considerable depth and drawn with some velocity through the water. The dredge we have been in the habit of using for several years past is made of cast-iron, which reduces the cost considerably—and it is in practice found to be sufficiently strong. It is about 18 inches in length, and the opening is about 4 inches wide—the two sides diverging outwards, at a slight angle, and coming to a sharp edge. It packs with the net-bag in a box about 2 feet long and 6 inches wide and high, and consequently makes a convenient-sized package. For the little information requisite in the use of the dredge, we would refer to Dr. Harvey's chapter on the subject, and will merely remark, that "dredging" will be found as pleasing and interesting a pursuit at the sea-side as any that can be there followed, and one that more than any other will, at times, be rewarded by an abundant harvest of objects of natural history.

Recommending our readers thus to invade the domains of Neptune, armed with microscope, towing-net, and dredge, we can assure them that no one will have cause, even in the most secluded nook of the coast, to complain of a single dull hour, and if he does not return to his labours reinvigorated both in body and mind, and with a fund of subjects for instructive contemplation for the year to come, all we can say is—that it will be entirely his own fault.

ON THE CONSTRUCTION AND USE OF THE MICROSCOPE. By ADOLPHE HANNOVER, MD., &c. Edited by JOHN GOODSIR, F.R.S.E., &c. Edinburgh. Sutherland and Knox. 1853, pp. 100.

DR. HANNOVER'S book is short, which is a great recommendation, and it contains many judicious and useful observations, and is evidently the production of an experienced microscopist; but we really can scarcely find in it much that should entitle it to appear in an English dress, as it is quite evident that the author is totally unacquainted with the present state of the microscope in this country, however familiar he may be with those of foreign construction. He does not mention, and appears to be unacquainted with any English microscope maker except Mr. Pritchard. Were he aware of what they have done, and still are daily doing, towards the perfection of the microscope as an instrument of scientific research, Dr. Hannover would surely have referred to the labours of Ross, Powell, and of Smith and Beck; men who, with the aid of Mr. Lister, have done more in the improvement of the achromatic microscope than all the continental opticians together, and whose instruments, both for optical perfection and mechanical contrivances are, as we believe, unrivalled by those of any country in the world. But we are indeed surprised that his learned English editor should have been content thus to ignore the merits of his countrymen, and to omit all notice of some of the most important improvements in the microscope and its appliances, which have now been long in daily use. Many other proofs of Dr. Hannover's want of information on the points to which we have referred might be adduced, but we would merely, in justification of what we have said, remark, that he appears to be quite ignorant that object-glasses may be made to adjust to varying thicknesses of the glass employed to cover an object (pp. 25, 59), although the mode in which this adjustment might be made was described by Mr. Ross as long ago as 1837, and has been universally adopted by English opticians since that time. He makes no mention either of any of the more recent, ingenious, and most valuable modes of illumination, to which, for some time past, so much and such successful attention has been paid. We refer more particularly to such contrivances as Gillett's condenser, and the parabolic reflectors of Wenham and Shadbolt.

The book, however, as we have said, contains many judicious observations and directions useful to the young microscopist; and the preliminary observations present, in a small compass and in plain language, as good an exposition of the principal optical considerations which are concerned in the structure and use of the microscope, as can, we think, be anywhere found within the same limits.

The first chapter is devoted to an account of the simple microscope; and chapter ii. is on the *construction* of the compound microscope and its accessories; but neither in these nor in the subsequent chapters, containing directions for the *use* of the instrument, do we observe anything from its novelty worthy of particular notice—at all events by those who have it in their power to refer to Mr. Quekett's much fuller and more practical work.

The author's observations on Micrometry are good, and will be found worth consultation, as is also what he says about the modes of estimating the magnifying power of an instrument, and for calculating the amount of spherical aberration of any combination (p. 75). With reference to this he takes occasion to remark, that the same mode of observation enabled him to judge whether his eyes had remained unchanged or not during four or five years, notwithstanding the almost daily use of the microscope. He found that during that period the sight of his right eye had become only 41-10·000ths =1-244th shorter; and observes, "this was satisfactory to myself, and it may also set those persons at rest who are fearful lest the use of the microscope should injure the eye"—which would be true were the alteration of the focal range of the eye the only consequence that can arise from the prolonged use of the microscope, especially by artificial light, against which we are fully in accord with Dr. Hannover, in warning all who have regard to the preservation of unimpaired visual powers.

We subjoin the following table of comparative micrometrical measures, given by Dr. Hannover, as it may be useful for reference in our pages :—

Millemetre.	Paris Lines.	Vienna Lines.	Rhenish Lines.	English Inch.
1	0·443296	0·4555550	0·458813	0·0393708
2·255829	1	1·027643	1·035003	0·0888138
2·195149	0·973101	1	1·0071625	0·0864248
2·179538	0·966181	0·992888	1	0·0858101
25·39954	11·25952	11·57076	11·65364	1

Mikroskopische Blicke in den inneren Bau und das Leben der Gewächse, &c. (Microscopical Glance into the Intimate Structure and Life of Plants. In the form of Popular Lectures.) By E. A. Rossmassler. With 15 mostly coloured lithographic plates. 118 pp. 8vo.

The whole is contained in four discourses. In the first the author compares the different modes in which natural history, or the idea contained in it, is comprehended by different classes of minds. To the one it is simply a chamber of mystery—to another a study—to a third a means of climbing to ease and renown—to a fourth a picture-book. To all, he says, it ought to be a "beautiful maternal home, to be a stranger in which should be regarded, in any one, as a loss and shame." He touches upon the question whether natural history is a real or merely a humanistic science, and decides in favour of the latter, seeing that the *homo* is still a part of the kingdom of nature—a convenient, but surely a dangerous argument! He lauds the value of the microscope in the natural sciences; and then proceeds, in more immediate application to his subject, to show, that plants consist of *cells*, explaining what is meant by the latter. In the second discourse the theme is continued; the peculiar forms of cells are described, and then the cell-contents: colouring matter, crystals, nucleus, starch, and the spiral filaments. The ensuing chapter discourses about the vessels and their modifications, and then adverts to the tissues formed immediately from the elementary organs, such as the cuticle with its stomata, hairs, setæ, and scales; to the structure of the leaf and ligneous stem in the mono- and dicotyledonous plants. The fourth chapter embraces the distinction between animals and plants, with respect to individuality and their various vital actions; the nutrition of plants and their importance with respect to the habitability of the earth; and lastly, the alternating relation between animals and plants. The last discourse treats of the root, the changes of matter effected in the interior of plants, the ascent and descent of the nutritive sap, and finally, of the parts belonging to fructification, and of fructification itself.

The illustrations, which are well designed and well executed, are copies from the larger figures employed by the author in his lectures. Of course in a work like this the utmost scientific precision is not to be expected nor many original views or facts; and the mode of treatment requisite in a course of popular lectures necessarily implies that many things must be superficially treated; we have no doubt, however, that the little work will obtain numerous readers, who will not fail to find in it an interesting and eloquent exposition of the subjects of which it professes to treat.

PRINCIPLES OF THE ANATOMY AND PHYSIOLOGY OF THE VEGETABLE CELL. By HUGO VON MOHL. Translated by ARTHUR HENFREY, F.R.S. London. Van Voorst.

THE use of the microscope alone has rendered the production of such a work as this possible. It is only a few years ago, if the existence of cells in plants was not altogether ignored, that their presence was regarded as a matter of little or no consequence, and vegetable physiologists speculated on the functions of plants, without knowing anything of the agencies by which they were produced. Microscopic research has, however, shown us that it is in the interior of these minute constituents of vegetable tissue that all the functions of plants are carried on. Hence we may truly say that the principles of the anatomy and physiology of the vegetable cell are the principles of vegetable anatomy and physiology.

To few men are we more indebted for the light that has been thrown on the functions of plants by the aid of the microscope than to Hugo von Mohl. From the time of one of his earliest publication on the pores of cellular tissue to the present, his contributions to the microscopic anatomy of plants have been very constant. To no one, therefore, could we listen more attentively on the subject of this work than to Hugo von Mohl. Nor is the subject of vegetable structure and physiology in so advanced a position as to leave little further to be done for its advancement. At present, the great proportion of our botanical literature gives indications that it is not yet emancipated from the influence of theories which were constructed at a time when only the most imperfect knowledge of the true structure of plants existed. Much of our vegetable physiology has to be reconstructed, and it is only by studying the phenomena of plant-life, as it presents itself in the simplest conditions, that we can expect to understand its more complicated forms. It is true that some of the younger botanists have thrown off altogether any allegiance to the older school of physiologists, and have determined to accept no theory that does not originate in microscopic research; but in them we have only the reaction that was a natural consequence of the new aspect which microscopic investigations gave to the functions of vegetable life. Amidst the different teachings of opposed schools, Hugo von Mohl will be found a safe guide for those who are anxious to understand the general laws which govern the life of the plant.

It must not, however, be supposed, that this is a work on morphological or systematic botany. The only point of view from which it contemplates the plant, is its origin, and that of all its parts, and the functions it performs, in the cell. To the amateur microscopist, to the animal physiologist, to the practitioner of medicine, to the student ambitious of grasping the general laws which govern the relations of the mineral, vegetable, and animal kingdoms, this work will supply those facts and principles in which they are each most interested. The matter is arranged under two principal heads, the anatomical conditions of the cell, and the physiological conditions of the cell—the cell at rest, and the cell in action. Under the first head, we have the form, the size, the walls, the contents, the relations, and the origin of the cell discussed. In the latter division, the cell is regarded—1. As an organ of nutrition; 2. As an organ of propagation; 3. As an organ of motion. In going over this wide field, Professor von Mohl discusses many controverted points, to some of which we should have been glad to have drawn attention had our space permitted. As he has distinguished himself by his researches upon the origin of the vegetable cell, we give an extract from this section of his work, relating to the differences of opinion which have existed between himself and Schleiden:—

To Schleiden belongs the merit of discovering free cell-formation and the dependence in which the origin of a cell stands to the formation of a nucleus; but he was led by this discovery to the misconception that this was the only mode of formation of the cell occurring in nature. In accordance with this hypothesis, the cells which were formed in other cells would always be much smaller than the parent-cells, and would gradually expand until they filled up the cavity of the parent-cells, and their walls came into contact. But as the whole process could not take place in cells which contain granular structures, such as chlorophyll or starch granules, or the like, without the displacement of these structures, and yet in a cell of that kind in which division occurs, all these structures are still present after the division, Schleiden invented an hypothesis to explain the circumstance, namely, that these structures in the cavity of the parent-cell were dissolved outside the secondary cell, and formed anew inside it. But as nothing of this process can be observed in nature, it alone suffices to refute the doctrine of the universality of free cell-formation. Even when quite recently, in consequence of Nägeli's observations, Schleiden (*Grundz.*, 3rd ed. i. 213) can no longer deny that a division of cells does occur, still he is far from acknowledging the universal diffusion of this process, since he only refers to the older notion, retracted by Nägeli himself, that this mode of formation occurs in the Phanerogamia or in the special parent-cells of the pollen-grains, and altogether ignores the fact that Nägeli and others have shown this to be the mode of formation of all cells except those originating in the embryo-sac; consequently, Schleiden still ascribes to free cell-formation an influence on the development of the plant which by no means belongs to it. When he states that the cells are developed in this way in the embryonal vesicle, this is decidedly false, for all recent observations agree in showing that the embryo originates from the germinal vesicle by cell-division; not less incorrect is it, that free cell-formation may be traced in jointed hairs, and just as little does it accord with the mode of formation of other plants that, as is stated (*Grundz.*, i. 211), cells are formed in cells, and the parent-cells absorbed, in the points of the roots and shoots of the stem of *Cypripedium*. The entire representation proves that Schleiden has never once observed the division of a cell.

The first account given by Schleiden (*Beitr. zur Phytogenesis, Muller's Archiv.*, 1848) of the process of cell-formation, was faulty in many respects. He altogether overlooked the important circumstance that the nitrogenous substances were the originators of the formation of the nuclei and the cell, for he believed the granules of protoplasm, which he denominated mucilage (*schleim*), to be identical with the granules of gum, and thought that the protoplasm might be replaced by starch, and go through similar metamorphoses; for he expressly mentions that starch, or the granular mucilage replacing it, is present in the pollen-tubes, but those substances are soon dissolved, or change into sugar or gum. In the formation of a nucleus those little mucilaginous granules were produced in the protoplasm, then a few larger granules, and soon afterwards the nuclei showed themselves. When a cell was formed, it had at first the form of a segment of a sphere, the plane side formed by the cytoblast, the convex side by the cell-membrane. Originally the cell-membrane was soluble in water, but it soon expanded more and more, and acquired greater consistence; and its walls, with the exception of the cytoblast, which always formed part of the wall, were composed of gelatine. The cell now soon became so large, that the cytoblast appeared only as a little body enclosed in the lateral wall. The cytoblast might go through the whole vital process with a cell, if it were not dissolved and absorbed in cells destined to higher development, either in its place, or after it had been cast off like an useless member, in the cavity of the cell.—The whole of this account of the relation of the nucleus to the cell-membrane is incorrect. The nucleus is not connected with the cell-membrane under any circumstances, for it is enclosed, with all the rest of the contents of the cell, in the primordial utricle. Its position in the newly originating cell is, as appears to me, always central, and its form mostly globular; it does certainly often lie upon the wall of the cell subsequently, and becomes flattened. The distinction which Nägeli tries to carry out between central and parietal nuclei is not founded in nature.

Another subject of no less interest to the vegetable physiologist, and to which Schleiden has given a peculiar view, is the origin of the embryo in Phanerogamic plants. The following is Mohl's account:—

When the pollen-tube has reached the upper part of the embryo-sac, its growth is either immediately arrested, or it becomes elongated a very little more, so that its obtuse, somewhat inflated end usually penetrates laterally between the embryo-sac and the surrounding cellular layer (pl. 1, fig. 14, 15), or, in rare cases (*Narcissus poeticus*, according to Hofmeister; *Digitalis purpurea*, and *Campanula Medium*, according to Tulasne), introverts the membrane of the embryo-sac for a short space. In extremely rare cases (in *Canna*, according to Hofmeister), the pollen-tube breaks through the membrane of the embryo-sac, and thus comes immediately in contact with the germinal vesicles. In the great majority of cases, however, as already observed, the pollen-tube is separated from the germinal vesicles by the membrane of the embryo-sac, and frequently even, the point at which the end of the pollen-tube is in contact with the embryo-sac, does not correspond exactly to the point at which a germinal vesicle lies in the inside of the embryo-sac (pl. 1, fig. 15). Therefore the only way in which a material effect can be produced by the pollen-tube upon the germinal vesicle, is by the fluid part of the fovilla transuding through the membranes of the pollen-tube, the embryo-sac, and the germinal vesicle. It cannot be demonstrated that such a transudation does take place, but it is in the highest degree probable, since it is incomprehensible how the impregnation of the germinal vesicle could take place without it.

The pollen-tube begins to decay more or less rapidly after it has reached the embryo-sac. Its growth is arrested, as before noticed, and the fovilla contained in it undergoes a visible change in its characters, acquiring a granular, half-coagulated aspect; the pollen-tube itself is by this time evidently dead, and disappears sooner or later (sometimes, however, not until the seed is ripe), apparently through absorption.

On this subject Professor Mohl appends the following criticism:—

Schleiden's theory of the origin of the embryo (*Einige Blicke auf die Entwickelungsgeschichte des veget. Organismus*, Wiegmann's *Archiv.*, 1837, 1, 289—*Ueber die Bildung des Eichens und Entstehung des Em-*

bryo, Act. acad. nat. Cur., v. xix., p. 1) is completely opposed to the foregoing description of this process, since, according to him, the embryo is not formed in the cavity of the embryo-sac, but in the lower end of the pollen-tube, which introverts the wall of the embryo-sac, and penetrates more or less deeply into the depression thus formed. If this theory were true, the germinal vesicle would not be an independent product of the ovule, but of the clavate, expanded extremity of the pollen-tube, and the suspensor would be the remainder of the latter, running into the introverted portion of the embryo-sac. In the whole province of Vegetable Physiology, seldom has a theory excited so much curiosity as this theory of impregnation. No conviction was more firmly established than that the pollen was the impregnating organ; hence the wonder that it should be exactly the reverse. The confusion was great, for the theory emanated from a man who showed by his numerous and excellent researches on the ovule, published at the same time, that he possessed an acquaintance with the subject, such as few others had, and who in every word expressed the conviction that the matter did occur as he asserted, and that a mistake was out of the question. And others were not wanting to make known confirmatory observations (Wydler, *Biblioth. Univers.*, 1838, Oct.; Géléznoff, *Bot. Zeitung*, 1843, 841), or to support the new doctrine on theoretical grounds, and teach it as a settled truth (Endlicher and Unger, *Grundz. der Botanik*). It is true that the old notion had its defenders, but these maintained the fight a long time with little success. Some who did not know how to use the microscope, thought, nevertheless, that an opinion might be arrived at here, in which the thing depended wholly and solely upon a fact to be determined by the microscope, from other grounds, but such was utterly without value by itself; others, Meyen in particular (*Physiologie*, iii.), certainly had recourse to the microscope, but were content with superficial observations, and thus were not very fortunate in their intended refutation of the new theory, for observations, in some of which not even the penetration of the pollen-tube into the ovule, or the embryo-sac were seen, were not calculated to drive an opponent like Schleiden out of the field, and the latter could justly interpret some among such discordant observations as Meyen's in his own favour. It was Amici again who now for the second time came forward with an observation marking an epoch in the theory of impregnation, and, by his researches on the impregnation of the Orchideæ (*Sulla fecundazione delle Orchidee,—Giorn. Bot. Italian, Anno* 2), made an end of the new theory at one blow. Amici's treatise was soon followed by a confirmation of what he had seen by myself (*Bot. Zeitung*, 1847, 465), and others; and these were quickly succeeded by the extensive researches of Hofmeister (*Die Entstehung d. Embryo d. Phanerogamen*) and of Tulasne (*Ann. d. Sc. nat. 3 Ser.* xii.), which contained a full confirmation of the results obtained in the Orchideæ, and demonstrated that the impregnative process is the same in its essential circumstances throughout a long series of Phanerogamia, so that this subject may be considered as quite settled in its principal features.

There are some who will probably not agree that this subject may be regarded as "quite settled," but we have not space to enter upon the discussion. We will conclude by cordially recommending this volume to all who are interested in the study of plants, but more especially to those who are anxious to gain a view of the grand distinguishing features of vegetable life, without entering upon the technical study of their structure, forms, and relations.

NOTES AND CORRESPONDENCE.

Mode of Determining the Optical Power of a Microscope.—I conclude by noticing another method of testing the optical power of the instrument, which, although rather troublesome, appears to me among the best, permitting us, as it does, to ascertain with a great degree of accuracy and certainty, the utmost limits of penetrating and separating power possessed by a microscope, and hence easily to express numerically its optical qualities in the most varied circumstances.

This method consists simply in subjecting to observation under the microscope the dioptric images of certain minute objects instead of the objects themselves. These images can be diminished at pleasure by withdrawing to a distance from the lens the object which forms them; and hence we have it in our power to measure the extreme limits at which the object continues to be visible.

For the formation of the dioptric images achromatic object-glasses might be used; but even where those of the shortest focal length are employed, the object whose image it is required to form must be placed at a great distance. This would cause various difficulties, and only be practicable with a microscope placed horizontally—unless, indeed, the object selected were very minute, in which case the accurate determination of its diameter (from which that of its image must be afterwards deduced) would be rendered difficult.

Small air-bells in a fluid are for this purpose far better. I employ by preference a watery solution of powdered gum arabic, which always contains numbers of such air-bells originating in the air entangled among the particles of the powder. The water employed should have stood for a considerable time freely exposed to the air, or been shaken up with the air for some time; for when we use water which is not saturated with air, the bubbles in the fluid gradually become smaller, and images formed in them decreasing in magnitude, cause errors in the subsequent measurements, as we shall actually find to be the case.

A drop of the fluid must then be placed on a clean glass object-slide, and covered with a good clear mica plate, a ring-shaped piece of paper being interposed, in order to prevent the flattening of the air-bells by pressure. The object-slide is then placed under the object-glass upon the stage of the microscope, and an air-bell of suitable size for the formation of the images is sought for. All do not give images of the same degree of sharpness; a peculiarity dependent on the fact that some air-bells are in contact with the covering-plate, and consequently have their spherical form disturbed to some extent, or on the presence of small molecules in the fluid above or beneath the air-bell, or even in its interior, causing some haziness of the image, just as defective polish of a glass lens would do. It will, however, be always easy to find some* which will form images of the utmost distinctness and purity. This may be ascertained in the first instance by holding between the mirror and stage some easily recognized object, *e.g.* a piece of paper or the like. The image is always formed on the under surface of the air-bell, which must consequently be brought nearer to the object-glass than when it is desired to bring its margins into focus.

The object whose image is to be the subject of examination should be placed upon an apparatus, which can be moved upwards and downwards in the space between the mirror and stage. In some microscopes this can hardly be done, either from the space being too limited, or in consequence of the drum-like form of the foot of the microscope which quite envelops the space. If such microscopes, in place of a mirror, be provided with a reflecting prism, the object may be placed opposite the side external to the microscope. The instruments best adapted for the manipulation which we are describing are, however, those whose illuminating apparatus consists of a mirror and converging lens, which can be shifted up or down. The lens being removed from the ring which supports it, the object is substituted in its place. The relative magnitudes of object and air-bell must be such that the image shall be exceedingly minute when the object is tolerably near to the stage. On afterwards increasing the distance between the object and air-bell, it is not difficult to find the limit at which the image (under a given magnifying power) is barely visible.

Of course it is impossible to measure *directly* the dimensions of this most minute visible image, for our best micrometric methods will here be found of no avail. Yet their size

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* The following example will demonstrate this. I brought a printed page of a book to such a distance from an air-bell that the length of the image of the whole page was 1-7th millimetre = about 1-180th of an inch, and that of the image of each letter about 1-480th millim. = 1-12,000th of an inch. In spite of their minuteness, these images, formed by reflected light, possessed such clearness and sharpness, that under a magnifying power of 154 diameters the whole page was without difficulty legible.

may be estimated with extreme accuracy in the following manner. At the same distance from the air-bell and in place of the object used, substitute another body, such as a piece of card, of 4 to 5 centimetres = $1\frac{3}{5}$ths to 2 inches diameter, which has been exactly measured. Let this be now again measured (by some of the micrometric methods elsewhere alluded to *), just as if it were a real object. By dividing the real diameter by the apparent diameter, the amount of diminution is found; and this is the same for all objects at a like distance from the air-bell. We have, consequently, nothing to do, in order to find the amount of diminution of the image of the more minute object, but to divide its *true* diameter by the figure expressing the diminishing power.

For example, let the true diameter of the greater object be 5 centimetres = to 1·969 English inches, and the diameter of its image = 32·2 micromillemetres,† = ·00127 English inches, then the figure expressing the amount of diminution will be $\frac{1\cdot969}{\cdot00127}$ = 1553 very nearly. If now the smaller object have a diameter of 175 micromillimetres = ·00689 English inches, then must its image at the limit of vision be in diameter = $\frac{\cdot00689}{1553}$ = ·0000044, or about $\frac{1}{225,000}$th of an English inch. When exact micrometric methods are employed, it is easy in this way to estimate the diameter of an image even to millionth parts of a millimetre, *i. e.* to 25,400,000th parts of an inch.

As for the object suitable for these investigations, it is plain that we have an extensive choice. To find the limit of vision for bodies of a round or long thread-like form, grains of pearl sago, or vegetable bodies, such as mustard-seed or the pollen-granules of many plants, hairs of animals, metallic wires, &c., may be employed. Small round openings and chinks may serve for the determination of the visibility of positive images of light. In the last case care must of course be taken, by means of suitable screens, to shut off all light except what passes through the aperture. To determine the defining power, metallic wire-gauze is a suitable object, or two holes placed near each other in a black metallic plate. The images of such objects resemble exactly a double star viewed through a telescope (kijker). The bodies may likewise be placed in different circumstances in order to ascertain the influence of these upon the limits of vision. Thus we may use as an object a very thin glass capillary-tube placed in water, and compare it with tender organic-tubes and vessels, which may also be

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* See translation from *Het Mikroskoop* in Monthly Journal of Medical Science, June 1852, p. 453, *et seq.*

† The micromillimetre is equal 1-1000th millimetres = ·0000394 English inches. See *Monthly Journal*, June 1852, p. 456.

seen in water, but whose limit of visibility is of course far more circumscribed than that of absolutely opaque objects.

In fact this method admits of innumerable variations, and is consequently of most extensive application. Besides, when proper precautions are taken, it gives results perfectly sure and comparable. Especial care is however requisite in the mode of illumination. For it is certain, that when the field has a clear white ground, the contrast causes minute opaque bodies (*i. e.* objects which are dark by transmitted light) to continue visible, which against a grayish or light-blue back-ground could not be seen. Hence it is by no means indifferent to receive on the mirror light from a white cloud, from a dull overcast, or clear blue sky. Artificial light cannot be used in these experiments, for the image of the flame becomes diminished like the object, and hence a clear field of view is not to be obtained. The observations must consequently be made by daylight; and whenever comparable results are sought for, the mirror should always be directed to the clear, blue, cloudless sky—this being a distinct atmospheric condition to which others in similar circumstances may refer in conducting the same experiment. The mode of ascertaining the limit of vision, with a given amount of illumination, may be gathered from different examples in the body of this work. It will likewise be found that for all such observations, even when the highest magnifying powers are employed, the *flat* mirror is perfectly sufficient, since in the image in the field of view formed by the air-bell, all the rays proceeding from the mirror are united and constitute an object of considerable luminous intensity.—PROFESSOR HARTING, *Utrecht.—Monthly Journal of Medical Science.*

On a New Animalcule.—The animalcules described in the following pages were found in great numbers in the bottom of a small vessel or "aquarium," in which colonies of *Plumatella*, *Melicerta*, and *Limnias* had been kept. Of all the forms which can with certainty be referred to the animal kingdom, there are few which at first sight are so little likely to be recognized as animals as those about to be described.

If the reader will imagine a bag made of some soft extensible material, so thin as to be transparent like glass, so soft as to yield readily by extension when subjected to internal pressure, and so small as to be microscopic; this bag, filled with particles of sand, shells of Diatomaceæ, portions of Algæ or Desmidieæ, and with fragments of variously coloured cotton, woollen, and linen fibres, will give a picture of the animal; to complete which it is only necessary to add a few loose strings to the bag, to represent the variable radiant processes which it possesses around the mouth.

When I first saw these curious creatures they attracted but little attention, as I supposed they were merely excrementitious masses due to some of the aquatic animals living in the vessel where they occurred. A more careful examination showed that they moved spontaneously, and even with some degree of rapidity; and that this motion was due to radiant, branching, and variable feelers, or "rhizopods," which were thrown out near one extremity. By attaching these feelers to various objects the animal was enabled by means of them to pull itself along, or to change its position at will.

The most common form in which these creatures occur is that of a pear-shaped mass having the feelers attached to the larger end, while the other end appears almost always to be pushed out, and rendered acute by the presence of several long diatomaceous shells which the animals have swallowed.

Another curious set of forms appears to be produced by the process of spontaneous fission or self-division.

The partial fission, or a budding from the sides, when combined with the distortion produced by the internal pressure of the various articles swallowed, gives rise to a variety of complex and extraordinary forms. Some of these appear as if several pear-shaped individuals were about to be produced by a budding from the sides of the parent, but it is also certain that some at least of these sac-like projections are only temporary extensions produced by internal pressure. This was decided beyond a doubt by a series of continued observations upon single individuals.

The substance of which these animals are composed is much like that composing the bodies of the various species of *Amoeba*, being soft, colourless, elastic, and extensible. It is probably without any true integument, and is coloured yellow by tincture of iodine. It appears to resist internal pressure with considerable force, and it is but rarely that it appears to be completely broken through by any of the matters, however hard, which are contained within it. I have, however, found some individuals which had voluntarily impaled themselves upon long fibres which were distinctly seen projecting through the animalcules at each end, and these animals were seen moving freely along, from one end of the fibre to the other, without appearing to experience any inconvenience from the perforation. I have occasionally found them attached in this way to filaments of *Conferva* and *Draparnaldia*, which were still alive at one extremity. The traces of internal structure or organization are exceedingly slight. Occasionally, when a portion of the body is left vacant, some slender thread-like lines may be seen in the interior.

In many individuals I have seen the protrusion from the mouth of transparent, rounded masses, which rapidly succeeded each other until they were heaped up about the mouth like a set of soap-bubbles, and were then as rapidly drawn in again. The more common appearance, however, is that where the mouth is surrounded by a considerable number of slender, colourless, radiant, branching, and retractile feelers, precisely like the rhizopods belonging to the marine Foraminifera or Polythalamia. When fully extended, these often exceed in length that of the body of the animal. They change rapidly from simple to branched, or *vice versâ*, and are at one moment seen in a state of tension, and then wrinkled and collapsed, or changed into various rounded processes, which can be wholly retracted. These feelers, tentacles, variable processes, or rhizopods are not like the pseudopods of Amoeba, mere protrusions of the surface, nor are they thrown out as in that genus, from all parts of the animal. They, on the contrary, resemble those of a *Difflugia*, in being confined to the vicinity of the mouth; but they are much more slender and more repeatedly branched than in any *Difflugia* which I have seen. By means of these organs the animals pull themselves along, when lying upon their side, and they also creep by means of them, with the mouth downwards, moving onwards with a slow gliding motion like that of a *Difflugia*.

Besides the heterogeneous collection of matters which these animals swallow, and which can be seen distinctly with all the forms and colours through the transparent exterior, there is also, in most specimens, a considerable number of small globules scattered without order, whose nature is very doubtful, for as yet there is no proof whether they are ova, oil drops, or something else.

When these creatures have swallowed bits of fibres which have been dyed of various colours, the reds, blues, scarlets, &c. of these filaments may be distinctly perceived through the sides of the animal; but the spectacle becomes still more curious when seen by polarized light, when the particles of quartz, &c., contained within these creatures also display their gorgeous tints.

When these creatures are dried upon glass, and then mounted in balsam, their forms are not greatly altered, and their contents become still more distinctly visible. It seems scarcely probable that these animals have so little discrimination as to swallow for food all the strange mixtures of organic and inorganic bodies which are found within them. It is possible, however, that adhering to these grains of sand, fibres of wool, &c., there may be nutritive matters deposited from the water, which may be removed by the process of digestion, as the soft contents of the shells of Diatomaceæ also appear to be. This view is supported by the fact, that on the application of tincture of iodine to these animals, a distinct blue colour was often seen all over the surface of many of the grains of sand in their stomach. The starch giving rise to this colour, was doubtless derived from bits of boiled beans and potatoes which had occasionally been introduced into the aquarium as food for other animalcules. Another fact which appears to show that the sand, &c., is not swallowed merely to increase the absorbing surface, as Dujardin suggests may be the case in Amoeba, is that these particles of sand are not retained for any great length of time, but in company with the empty shells of Diatomaceæ, and other remains of their food, they are, after a while, thrown out at the mouth, which appears to be the only aperture for their reception and discharge. There appears to be no reason to doubt that the cavity into which all these bodies are received is a true stomach, and they therefore manifestly cannot be considered as polygastric animals. As to the position of these creatures in the system of Zoology, it is evident that they belong to the Infusorial Rhizopoda of Dujardin, and connect the genus *Amoeba* with *Difflugia*, agreeing with the first in the soft body without shell, but differing in having true feelers or rhizopods confined to the anterior portion of their body, and by not throwing pseudopods from other parts. From *Difflugia* and the whole family of *Arcellina*, these forms are distinguished by having no lorica or shell. They are, however, closely allied to the *Arcellina*, and are very nearly what some of the species of this group would be, if deprived of their rigid external coverings.

In order to give to these curious beings at least a temporary name and place, I propose to found for their reception a new genus named and characterized as follows, viz.:—

Pamphagus, nov. gen.

Animals of the class of Rhizopoda (intermediate between *Amoeba* and *Arcellina*) without shell or lorica, and composed of a soft, colourless matter, easily extended by internal pressure, but not spontaneously protruded into pseudopods. Feelers or rhizopods, slender, numerous, radiant, branching, and confined to the neighbourhood of the mouth.

Species 1. *Pamphagus mutabilis.*—This species, which is the only one now known, is sufficiently described above. Its habitat is probably the bottom of small pools and streams of fresh water, as it was found in vast numbers in an aquarium supplied from such places in the vicinity of West Point. It will probably be found to be a common form; and as it presents the conditions of animal life in almost the lowest degree of simplicity, and can be preserved and studied with great ease, it will well reward the attention of microscopists. I have thousands of these animals now living in mid-winter, and with a little care they may probably be kept until the return of warm weather, when other interesting facts may possibly be added to the observations here recorded. J. W. Bailey.—*American Journal of Science and Arts*, vol. xv.

On certain peculiar Structures in the Placenta of the Bitch.—The placenta in this animal forms a circular band with distinctly-marked margins, on each of which, at and near the conclusion of gestation, is an olive-green, almost black, line, having the appearance of coagulated blood. On placing a portion of this dark matter under the microscope, and examining it with powers varying from 200 to 600 diameters, it was seen to contain numerous unaltered blood discs; cells containing a bluish-green, and other cells filled with a deep red, colouring matter. The cells containing the red-colouring matter were almost opaque, and bore a striking resemblance to the nodules of colouring matter so constantly seen in the spleens of animals. The bluish-green colouring matter contained in the other cells varied in tint, from brilliant blue to bluish green, and light green in different cells. Both kinds of colouring matter were insoluble in water, but soluble in acetic acid and solution of caustic potass. These colouring matters were evidently enclosed in distinct cells, of which the membrane could be readily distinguished. The cells varied in form; were rounded, oval, sometimes agglutinated in masses, and often very irregular. The cells varied in diameter, from 1-2400 to 1-343 of an inch; some of those containing the red-colouring matter being as small as 1-3430 of an inch.

In addition to these colour-containing cells, an immense multitude of minute crystals, of a light reddish tint, were diffused over the field. They had the form of elongated, flattened prisms, either with distinctly truncated or irregular extremities. The colour varied from distinct red, with a play of prismatic colours, to colourless. The more minute of the crystals showed little colour, as might be expected, since the red corpuscles of the blood appear scarcely coloured when viewed with a high power under a strong light. These crystals varied in length, from 1-171 to 1-1828 of an inch, and in breadth, from 1-2400 to 1-15,000th of an inch.

With regard to the origin of these colouring matters, it seems sufficiently evident that they are produced by a metamorphosis of the hœmatin of the blood-discs; and it is by no means improbable that the crystals consist of nothing more than the altered colouring matter of effused and stagnant blood. Similar crystals have been described by Kölliker in specimens of effused blood, in the blood of the portal vein, and in the spleen; and by Dr. Parkes and others in putrid blood. They are interesting as exhibiting the crystallization of a purely organic principle within the living and healthy body.—Philip B. Ayres, M.D., London.

Fig. 1.

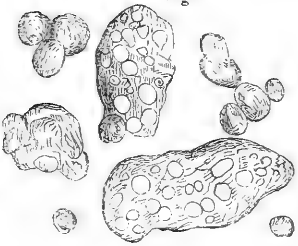


Fig. 2

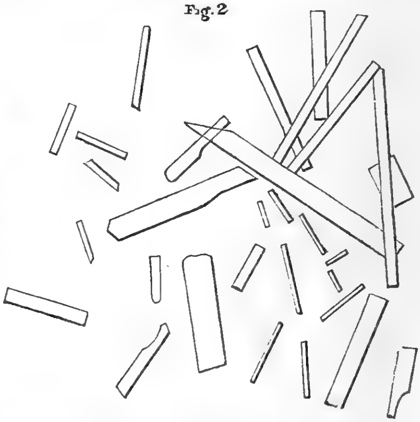


Fig. 3.

Fig. 1 represents cells from the margin of the placenta of the bitch, containing blue and reddish-brown colouring matter, often in granules; but these have neither the diameter nor appearance of blood discs. 400 diameters.

Fig. 2. Crystals contained in the tissues of the margin of the placenta of the bitch, but not enclosed in cells, having a yellowish or reddish tint under the microscope. 400 diameters.

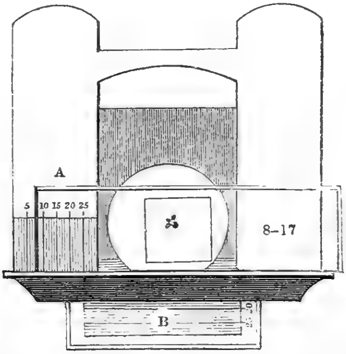
Fig. 3. Vibriones from putrescent urine, showing the transverse lines which indicate spontaneous divisions. 600 diameters.

All the figures were drawn with the camera lucida.

Vibriones.—Whenever an animal fluid, or water containing a portion of animal substance, is allowed to stand aside for a few days, until putrefaction commences, a multitude of minute, active animalcules, of an elongated cylindrical form, may be seen moving through it, which have received the name of Vibriones. These animalcules are so minute and transparent, that no internal structure can be seen with a power of 600 or 900 diameters; the highest powers with which I have had the opportunity of observing them. They have been viewed by some naturalists as the efficient agents or excitors of putrefaction, in the same sense that the yeast-plant is the excitor of fermentation in saccharine fluids; but this opinion is not as yet decisively determined, although the experiments of Professor Schultze, and, so far as I have been able to observe, their universal presence in putrescent fluids, seem to corroborate it. Considerable difference is seen in the length of different individuals, some being as long as 1-600 of an inch, while the shortest is 1-6000, the average length being 1-4000 to 1-2000. Although the variation in length is so great, all of them retain nearly the same transverse diameter, which is under 1-12,000 of an inch. This circumstance, together with the immense rapidity of their formation in a putrefying fluid, points to a fissiparous mode of reproduction; but this, so far as I have been able to ascertain, has not been described. In examining some putrescent urine last year, in which there were a large number of these animalcules, I observed that, while the shortest of the vibriones were in active motion, the longer ones were comparatively quiescent; and that these exhibited, according to their length, from one to six transverse lines, indicating the points of separation in the reproductive process. Those of moderate length, presenting only one or two transverse lines, were rather active, and often bent at an angle at the transverse line, which presented the appearance of separation into two distinct individuals, and the character of the movements appeared such as to favour the separation. Those with from three to six transverse lines were, for the most part, quiescent. I imagined, although from their excessive minuteness and transparency this was not plainly and unequivocally discernible, that there were indentations of the extremities of the transverse lines by which constrictions were produced, which by their increase would finally effect a complete transverse division of the animal (Fig. 3). These animalcules deserve a careful examination by those microscopists who possess higher powers, on account of their intimate connexion with the process of putrefaction.—PHILIP B. AYRES, M.D., London.

Finder.—Observing in the last number of the Quarterly Journal, an ingenious *Finder* for microscopists, suggested by Mr. Tyrrell, I send a plan I have used some time for the same purpose, adapted for minute objects and high powers. On the thinnest writing paper, in a space one inch long and half an inch deep, I rule about 30 divisions to the inch, vertically, leaving on the top space to designate the numbers of the lines; this slip so ruled, I fasten with Rotham's India

Rubber Paste on the left side of the sliding object plate (fig. A), with the bottom of the lines close to the lower ledge used for the support of the object slide, &c.; I also rule another paper one and half inch long, and one inch deep, with horizontal lines also about thirty to an inch, numbering them on each side as above, and paste the paper so ruled on the bottom of the brass piece of the stage (B) on which the slide moves,

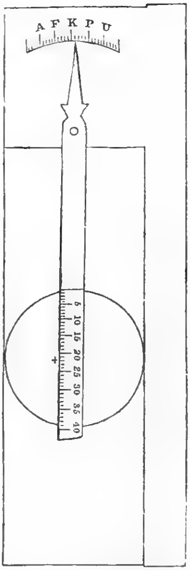


so that the slide will pass over the paper, and cutting out a half circle in the paper for the hole in the under plate, leaving lines on each side the said hole. When I wish to fix the finding of any minute object, I adjust the moveable stage exactly square, by a mark made for the purpose on the upper and lower parts (slips of paper pasted on each will do), and find the object by moving the slide plate and slip of glass on which the object is placed, till the latter is in the centre of the eye-piece, and then observe the number of the line the left hand end of the glass slip touches on the vertical scale, and also the number of the line the bottom of the sliding plate rests on in the horizontal scale—say No. 7 the first, and 15 the latter—I then mark on the right hand end of slide or glass slip 7 and 15, and when so placed again the object is easily found. It is very requisite, however, *the stage should always be adjusted to the mark* before the left hand end of the slide or slip and the bottom of the sliding plate are placed according to the numbers. The above scales are easily made, and affixed to every microscope with a sliding plate, or may be engraved on the plate at a small expense. By placing these scales at right angles to each other on a plain stage, the same end may be attained, and in a simpler manner.—E. G. WRIGHT, *Hereford.*

The Finder.—I take the liberty of submitting to your notice a modification of Mr. Tyrrell's useful instrument the

“Finder,” adapted for use on the plain stages of foreign or other microscopes. It gives at a glance, as you will see, the *latitude* and *longitude*, so to speak, of the object sought, and saves an infinity of time and trouble in hunting over uneven surfaces—such, for instance, as fragments of flint containing Xanthidia, where ordinarily the focal adjustments are constantly at work.

Take a thin, flat piece of boxwood, one inch and a quarter broad, and four inches long. Along the top of this fasten another piece, thicker than your slides, a quarter of an inch broad, and also four inches long. Next, to the left side glue a piece of the same thickness and one inch square, and upon this a scale is to be ruled, divided into fortieths of an inch, each mark representing a *letter* of the alphabet. Now remove the middle inch from the three that remain uncovered of the flat piece, as far as the upper shoulder. Next take a very thin slip of ivory, about a quarter of an inch broad, and two inches and three quarters long, point one of its ends, and bore a hole for a pivot five-eighths of an inch from the apex; at the other end mark an inch scale into fortieths, and *number* the divisions by fives. This slip is to turn on its pivot near the right hand edge of the raised portion to the left, in such a manner that its own scale may mark the longitude in *numbers* of any object in the field, while its pointed end will give the latitude on the *lettered* scale of the boxwood.



The exact position of the object (+) in the accompanying sketch is L. 22. The letters A, F, K, P, U, are used to every long fifth line; the shorts indicate the intervening letters.—THOMAS EDWARD AMYOT, *Diss*, *Norfolk*.

The Finder.—Since reading the description of Mr. Tyrrell’s “Finder,” given in the last number of the Microscopical Journal, I have adopted a modification of it which is far more simple, and appears to possess several advantages over a separate scale. My plan is to make a fine scratch, either with a writing diamond or the broken end of a three-square file, near the edge of the slide, directly opposite to the specimen of which it is desired to preserve the exact locality, so as to be able to find it again at any future moment. The method of using this is the same as in the original, with this exception, that, instead of being bothered with counting the intermediate divisions of the scale, the edge of the slide being brought into the field, it may be moved horizontally until the scratch be seen, and by using the vertical movement the object itself is soon discovered. Of course, several objects may be thus denoted in the same slide, as both edges may be marked with several lines each, and which may be so faint as not to disfigure the slide in appearance. In recording on the label each individual thus indexed, either end of the name may have the number of the mark placed to correspond with that edge of the glass which contains it.

To prepare the slide thus is extremely simple and easy. In the first place a fine notch must be cut on the inner edge and near the middle of the cross bar at the bottom of the stage plate, and against which the glass slide rests when pressed in its place by the "clip:" let this notch be brought into the centre of the field and the *vertical* movement alone be made use of. For the horizontal, the slide itself must be moved upon the stage plate until the desired specimen be found: then bring the notch upon the bar again into the field, to see that the two, the object and the notch, may both be in the centre of the field, using the vertical movement on the sliding plate of the stage. If the slide be held firmly by the clip (I use a piece of cork in preference to a metallic spring), the plate may be slid off and then marked with the greatest accuracy.

I have objects which may thus be readily found with a quarter-inch object glass, and when once carefully marked the slides are available at all times or with any instrument, and are far more convenient in every respect, as well as less unsightly, than when the discs are disfigured by rings scratched or painted on the surface.—W. K. Bridgman, *Norwich.*

Professor Riddell's Binocular Microscope.—Your April number, I perceive, contains some notice of my binocular microscope, &c., from Silliman's Journal. I have completed two elaborate models of this instrument, both of which work to admiration. I enclose you a printed slip from the April number of the New Orleans 'Monthly Medical Register,' from which you may get an idea of my latest modification:—

Professor Riddell, the original inventor of the binocular microscope, exhibited and explained a simplification of that important instrument, by which, at an expense not necessarily exceeding thirty or forty dollars, it is practicable, in existing compound microscopes of the ordinary forms, to replace the brass tube carrying the ocular and objective, by an efficient arrangement for binocular vision. To accomplish an equal division of the pencil of light immediately behind the objective, and to effect its distribution to each ocular, only two glass prisms need be used. They must be of such form, that the faces, at which the light is immergent and emergent, shall form equal angles with the face on which the internal reflection occurs. The chromatic dispersion is a minimum, and really nothing, when these angles are each near eighty-seven degrees. This form is theoretically preferable. In the instrument constructed, and shown by Professor Riddell, the French rectangular prisms, such as sold by most opticians, were used, in which the equal angles alluded to are forty-five degrees. The long sides of these, which are the reflecting surfaces, face each other, and, while the edges next the objective are in contact, the upper edges are adjustable, so as to vary at pleasure the inclination of the prisms to each other. In its transit through these prisms, the light is reflected internally, and undergoes two refractions which are almost mutually compensatory. The result is satisfactory. To produce orthoscopic binocular vision, simple, not erecting eye-pieces, are required.

While making microscopical dissections, it is convenient to have the free use of both hands. This convenience I command by connecting the fine focus movement with a delicate piston-rod, which is moveable by breathing through a flexible tube. This plan works admirably.—J. L. RIDDELL, *New Orleans, May* 25, 1853.

Localities of Microscopic Plants and Animals.—For the information of microscopical observers resident in and near the metropolis, allow me to state that the following species, in addition to commoner ones which I do not think it necessary to specify, may be found in the freshwater and brackish ditches in the parish of Milton-next-Gravesend:—

Surirella striatula
——— Gemma
Aneurea squamata
——— striata
Nitschia reversa
——— Closterium
Gallionella nummuloides
Cosmarium crenatum
——— undulatum
Synedra valens
——— biceps
——— acicularis
——— radians
——— lunaris
Synedra Ulna
Amphora ovalis
Cymbella Ehrenbergii
Cyclotella Kutzingiana
Gomphonema olivaceum
Bacillaria paradoxa
Leucophrys patula
Coleps hirtus
Nassula elegans
Schizonema
Euplotes Charon
——— truncatus
Pleurosigma Hippocampus
——— elongatum.

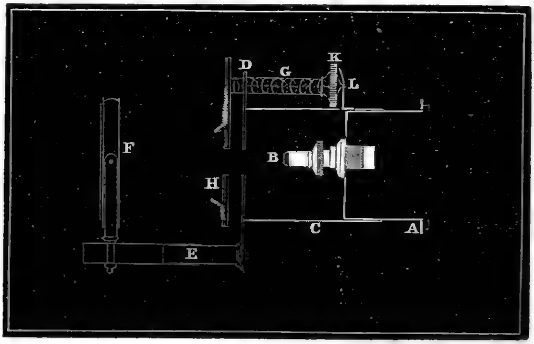
On the north side of the Serpentine, Hyde Park, especially near the bridge, may be found:—

Cymbella maculata
Gomphonema cristatum
Scenedesmus quadricauda
——— obliquus
Ankistrodesmus falcatus
Pediastrum Heptactys
Cocconema lanceolatum
Amphora ovalis
Cocconeis placentula
Uvella hyalina
Gallionella nummuloides
Euastrum elegans
Pyxidula operculata.

J. M. R.

Microscope Camera.—In the last number of this Journal, I suggested an arrangement (fig. 12) for taking photographs of microscopic objects. Since then I have perfected this;

and as it is very compact, steady, and ever ready for immediate use, I think it may be found advantageous to those who are constantly employing photography in its application to the microscope. A tube, A, screws into the flange of a camera which has a range of twenty-four inches; the front of this tube is closed, and into it screws the object-glass, B. Over A slides another tube, C; this is closed by a plate, D, which extends beyond the upper and lower circumference of C, and carries a small tube, E, on which the mirror, F, is adjusted. To the upper part of D the fine adjustment G is attached; this consists of a spring wire coil acting on an inner tube to which the stage-plate, H, is fixed, and is regulated by a graduated head, K, acting on a fine screw likewise attached to the stage-plate, after the manner of Oberhauser's microscopes. An index, L, is fixed opposite the graduated head, K. The stage and clamp slides vertically on H, and by sliding this up or down, and the glass object-slide horizontally, the requisite amount of movement is obtained to bring the object into the field. The object being brought into view, the image is roughly adjusted on the focussing-glass by sliding C on A; the focussing is completed by aid of the fine adjustment, G, K, and allowance then made for the amount of non-coincidence between the chemical and visual foci of the object-glass. The difference in each glass employed should be ascertained by experiment in the first instance, and then noted. By employing a finely-ground focussing-glass greased with oil, this arrangement forms an agreeable method of viewing microscopical objects with both eyes, and is less fatiguing. As a very large field is presented to the observer, this arrangement might be advantageously employed for class demonstration.—Samuel Highley, Jun., *Fleet Street*.



PROCEEDINGS OF SOCIETIES.

ROYAL INSTITUTION OF GREAT BRITAIN.

A Lecture on the Identity of Structure of Plants and Animals

By THOMAS H. HUXLEY, Esq., F.R.S.

THE Lecturer commenced by referring to his endeavours last year to shew that the distinction between living creatures and those which do not live, consists in the fact, that while the latter tend to remain as they are, unless the operation of some external cause effect a change in their condition, the former have no such inertia, but pass spontaneously through a definite succession of states—different in kind and order of succession, for different species, but always identical in the members of the same species.

There is, however, another character of living bodies— *Organization;* which is usually supposed to be their most striking peculiarity, as contrasted with beings which do not live: and it was to the essential nature of organization that the Lecturer on the present occasion desired to direct attention.

An organized body does not necessarily possess organs in the physiological sense—parts, that is, which discharge some function necessary to the maintenance of the whole. Neither the germ nor the lowest animals and plants possess organs in this sense, and yet they are organized.

It is not mere external form, again, which constitutes organization. On the table there was a lead-tree (as it is called) which, a mere product of crystallization, possessed the complicated and graceful form of a delicate Fern. If a section were made of one of the leaflets of this tree, it would be found to possess a structure optically and chemically homogeneous throughout.

Make a section of any young portion of a true plant, and the result would be very different. It would be found to be neither chemically nor optically homogeneous, but to be composed of small definite masses containing a large quantity of nitrogen, imbedded in a homogeneous matrix having a very different chemical composition—containing in fact abundance of a peculiar substance—*Cellulose.*

The nitrogeneous bodies may be more or less solid or vesicular—and they may or may not be distinguished into a central mass (*nucleus* of Authors) and a peripheral portion (*Contents, Primordial utricle* of Authors)—on account of the confusion in the existing nomenclature, the Lecturer proposed the term *Endoplasts* for them.

The cellulose matrix, though at first unquestionably a homogeneous continuous substance, readily breaks up into definite portions surrounding each Endoplast,—and these portions have therefore conveniently, though, as the Lecturer considered, erroneously, been considered to be independent entities under the name of Cells:—these, by their union, and by the excretion of a hypothetical intercellular substance, being supposed to build up the matrix. On the other hand, the Lecturer endeavoured to shew that the existence of separate cells is purely imaginary, and that the possibility of breaking up the tissue of a plant into such bodies, depends simply upon the mode in which certain chemical and physical differences have arisen in the primarily homogeneous matrix, to which, in contradistinction to the Endoplast, he proposed to give the name of ***Periplast*** or ***Periplastic Substance.***

In all young animal tissues the structure is essentially the same, consisting of a homogeneous periplastic substance with imbedded Endoplasts (*nuclei* of Authors) as the Lecturer illustrated by reference to diagrams of young Cartilage, Connective Tissue, Muscle, Epithelium, &c. &c.; and he therefore drew the conclusion that the common structural character of living bodies as opposed to those which do not live, is the existence in the former of a local physico-chemical differentiation; while the latter are physically and chemically homogeneous throughout.

These facts, in their general outlines, have been well known since the promulgation, in 1838, of the celebrated Cell-theory of Schwann. Admitting to the fullest extent the service which this theory had done in Anatomy and Physiology, the Lecturer endeavoured to shew that it was nevertheless infected by a fundamental error, which had introduced confusion into all later attempts to compare the vegetable with the animal tissues. This error arose from the circumstance that when Schwann wrote, the primordial utricle in the vegetable-cell was unknown. Schwann, therefore, who started in his comparison of Animal with Vegetable Tissues from the structure of Cartilage, supposed that the corpuscle of the cartilage cavity was homologous with the "nucleus" of the vegetable cell, and that therefore all bodies in animal tissues, homologous with the cartilage corpuscles, were "nuclei." The latter conclusion is a necessary result of the premises, and therefore the Lecturer stated that he had carefully re-examined the structure of Cartilage, in order to determine which of its elements corresponded with the primordial utricle of the plant—the important missing structure of which Schwann had given no account—working subsequently from Cartilage to the different tissues with which it may be traced into direct or indirect continuity, and thus ascertaining the same point for them.

The general result of these investigations may be thus expressed: —*In all the animal tissues the so-called nucleus* (Endoplast) *is the homologue of the primordial utricle* (*with nucleus and contents*) (Endoplast) *of the Plant, the other histological elements being invariably modifications of the periplastic substance.*

Upon this view we find that all the discrepancies which had appeared to exist between the Animal and Vegetable Structures disappear, and it becomes easy to trace the *absolute identity* of plan in the two,—the differences between them being produced merely by the nature and form of the deposits in, or modifications of, the periplastic substance.

Thus in the Plant, the Endoplast of the young tissue becomes a "primordial utricle," in which a central mass, the "nucleus," may or may not arise; persisting for a longer or for a shorter time, it may grow, divide and subdivide, but it never (?) becomes metamorphosed into any kind of tissue.

The periplastic substance follows to some extent the changes of the Endoplast, inasmuch as it generally, though not always, grows in when the latter has divided, so as to separate the two newly formed portions from one another; but it must be carefully borne in mind, though it is a point which has been greatly overlooked, that it undergoes its own peculiar metamorphoses quite independently of the endoplast.—This the Lecturer illustrated by the striking case of the Sphagnum leaf, in which the peculiarly thickened cells can be shewn to acquire their thickening fibre *after the total disappearance of the primordial utricle*,—and he further quoted M. von Möhl's observations as to the early disappearance of the primordial utricle in woody cells in general,—in confirmation of the same views.

Now these metamorphoses of the periplastic substance are twofold: 1, Chemical; 2, Morphological.

The Chemical changes may consist in the conversion of the cellulose into xylogen, &c., &c., or in the deposit of salts, silica, &c. in the periplastic substance. Again, the periplastic substance around each Endoplast may remain of one chemical composition, or it may be different in the outer part (so-called intercellular substance) from what it is in the inner (so-called cell-wall).

As to Morphological changes in the periplastic substance, they consist either in the development of cavities in its substance—*vacuolation* (development of so-called intercellular passages) or in *fibrillation* (spiral fibres, &c.).

It is precisely the same in the Animal.

The Endoplast may here become differentiated into a nucleus and a primordial utricle (as sometimes in Cartilage), or more usually it does not—one or two small solid particles merely arising or existing from the first, as the so-called "*nucleoli*;"—it persists for a longer or shorter time; it divides and subdivides, but it never (except perhaps in the case of the spermatozoa and the thread-cells of Medusæ, &c) becomes metamorphosed into any tissue.

The periplastic substance, on the other hand, undergoes quite independent modifications. By chemical change or deposit it acquires Horn, Collagen, Chondrin, Syntonin, Fats, Calcareous Salts, according as it becomes Epithelium, Connective Tissue, Cartilage, Muscle, Nerve, or Bone, and in some cases the chemical change in the immediate neighbourhood of the endoplast is different from that which has taken place exteriorly,—so that the one portion becomes separable from the other by chemical or mechanical means; —whence, for instance, has arisen the assumption of distinct walls for the bone-lacunæ and cartilage-cavities; of cell-contents and of intercellular substance as distinct histological elements.

The Morphological changes in the periplastic substance of the animal, again, are of the same nature as in the plant:—Vacuolation and Fibrillation (by which latter term is understood, not only the actual breaking up of a tissue in definite lines, but the tendency to do so)—*Vacuolation* of the periplastic substance is seen to its greatest extent in the "Areolar" connective tissue;—*Fibrillation* in tendons, fibro-cartilages, and muscles.

In both Plants and Animals, then, there is one histological element, the Endoplast, which does nothing but grow and vegetatively repeat itself; the other element, the periplastic substance, being the subject of all the chemical and morphological metamorphoses, in consequence of which specific Tissues arise. The differences between the two kingdoms are, mainly, 1. That in the Plant the Endoplast grows, and, as the primordial utricle, attains a large comparative size;—while in the Animal the Endoplast remains small, the principal bulk of its tissues being formed by the periplastic substance; and, 2, in the nature of the chemical changes which take place in the periplastic substance in each case. This distinction, however, does not always hold good, the Ascidians furnishing examples of animals whose periplastic substance contains cellulose.

"The Plant, then, is an animal confined in a wooden case, and Nature, like Sycorax, holds thousands of 'delicate Ariels' imprisoned within every Oak. She is jealous of letting us know this, and, among the higher and more conspicuous forms of Plants, reveals it only by such obscure manifestations as the shrinking of the Sensitive Plant, the sudden clasp of the Dionœa, or, still more slightly, by the phenomena of the Cyclosis. But among the immense variety of creatures which belong to the invisible world, she allows more liberty to her Dryads; and the Protococci, the Volvox, and indeed all the Algæ, are, during one period of their existence, as active as animals of a like grade in the scale. True, they are doomed eventually to shut themselves up within their wooden cages and remain quiescent, but in this respect they are no worse off than the Polype, or the Oyster even."

In conclusion, the Lecturer stated his opinion that the Cell-theory of Schwann consists of two portions of very unequal value, the one anatomical, the other physiological. So far as it was based upon an ultimate analysis of living beings and was an exhaustive expression of their anatomy, so far will it take its place among the great advances in Science. But its value is purely anatomical, and the attempts which have been made by its author, and by others, to base upon it some explanation of the Physiological phenomena of living beings by the assumption of Cell-force, Metabolic-force, &c. &c., cannot be said to be much more philosophical than the old notions of "the actions of the vessels," of which physiologists have lately taken so much pains to rid themselves.

"The living body has often, and justly, been called, 'the House we live in;'—suppose that one, ignorant of the mode in which a house is built, were to pull it to pieces, and find it to be composed of bricks and mortar,—would it be very philosophical on his part to suppose that the house was built by *brick-force?* But this is just what has been done with the human body.—We have broken it up into 'cells,' and now we account for its genesis by cell-force."

[T. H. H.]

MICROSCOPICAL SOCIETY.

April 27, 1853. *George Jackson, Esq., President, in the Chair.*—A communication from Professor Wheatstone on 'The Binocular Microscope, and on Stereoscopic Pictures of Microscopic Objects' was made by Dr. Lankester. (See Transactions in present Number of Journal.)

May 25, 1853. *The President in the Chair.*—A communication was made by Mr. Wenham on 'The Construction of Binocular Microscopes.' He exhibited an instrument constructed under his direction by Messrs. Smith and Beck (whose promptness to execute the work he acknowledged) consisting of one object glass and two eye-pieces, in which the object was presented stereoscopically to the eye. This arrangement was effected by allowing the object to be refracted through two glass prisms so as to reach separately the two eye-pieces.

Mr. Shadbolt read a paper on 'Some new forms of Diatomaceæ from Port Natal.' Having alluded to the confused state of the nomenclature of the Foreign species of this family, and expressed a hope that the work now in course of publication by Messrs. Smith and Beck on the British species would lay the foundation for a more correct system, the author proceeded to describe particularly the novelties in a gathering from Port Natal, which contained no less than fifty-five species, of which twenty at least were new, including five of the genus *Triceratium*, two of *Pleurosigma*, and three of a new genus *Bacteriastrum*. From the nature of the forms it was concluded that the locality must have been subject to marine influence, and probably contiguous to some river.

June 22, 1853. *The President in the Chair.*—Mr. Legg communicated to the Society some 'Observations on the Examination of Sponge Sand, with Remarks on Collecting, Mounting, and Viewing Foraminiferæ.' Having observed that there was some degree of uniformity in the magnitude of several of the species of shells, the author assumed that by sifting the sand through sieves of different degrees of fineness much labour might be spared, and he therefore procured some pieces of wire gauze, varying from 10 to 100 wires to the inch, the result of which was fully equal to his expectation, many of the larger kinds being thus brought together in considerable abundance, and the mass cleared of 19-20ths of very fine material, containing a very small proportion of shells; this last-mentioned material was afterwards submitted to a process of washing by placing a quantity of the sand in a dish, covering it with water to the depth of half an inch, and gently agitating it so as to form little eddies, the minute shells were then found to be collected in distinct channels of a whiter aspect than the other parts, and were readily removed by means of a camel's-hair pencil.

The author then noticed the occurrence of Foraminiferous shells on the Smallmouth Sand, near Weymouth, in considerable abundance, by having remarked that the surface of the sand was distinctly marked by little ridges extending many yards in length, and parallel to the edge of the water; these portions, upon examination, proved to be minute shells. He also mentioned the occurrence of Foraminiferæ on the surface of the mud in Shoreham Harbour, and in the ouze from the Oyster-beds. From these evidences the author concluded that the surface alone of sand or mud banks should be collected with a view to finding these organisms.

The paper concluded with some practical remarks on mounting and viewing Foraminiferæ, in which the author recommended the annular condenser of Mr. Shadbolt, or the parabolic reflector of Mr. Wenham, as the best means of developing such of these objects as are of a transparent texture.

A paper was read from Mr. Rainey on a new mode of illuminating objects.

The President announced that arrangements had been made with the Editors of the Microscopical Journal, by which the members would be entitled to that publication without further payment as heretofore.

DESCRIPTION OF PLATE X.

Fig.

1. Lateral aspect of the Faujasina. *Magnified* 30 *diameters.*
2. Superficial section of the flat base of the shell. *Mag.* 60 *diameters.*
3. Horizontal section parallel to the last, across the points *b b*, in fig. 1. *Mag.* 60 *diameters.*
4. Horizontal section across the points *c c* in fig. 1. *Mag.* 60 *diameters.*
5. Vertical section across the points *d d* in fig. 1. *Mag.* 60 *diameters.*
6. Superficial section from the oblique side of the shell. *Mag.* 80 *diameters.*

Fig. 1

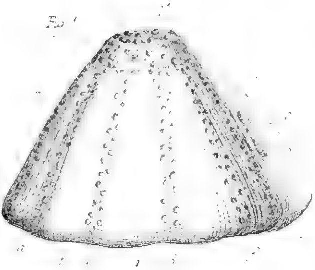


Fig.

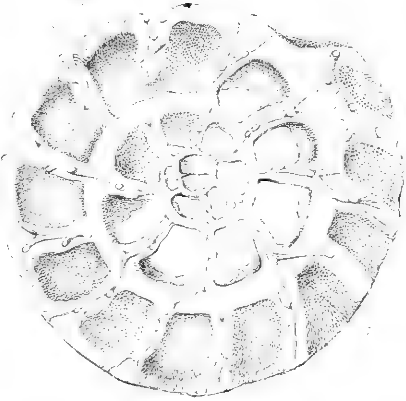


Fig.

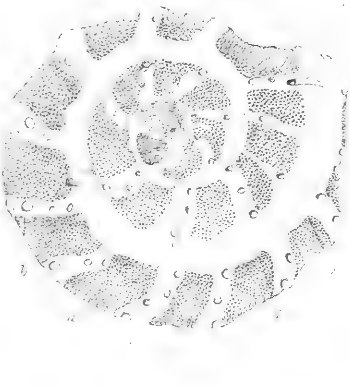


Fig. 4

Fig.

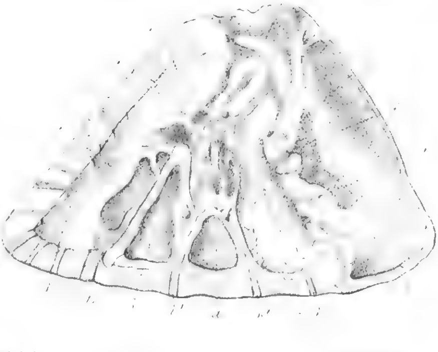


Fig.

W.C. Williamson del. Tuffen West sc.

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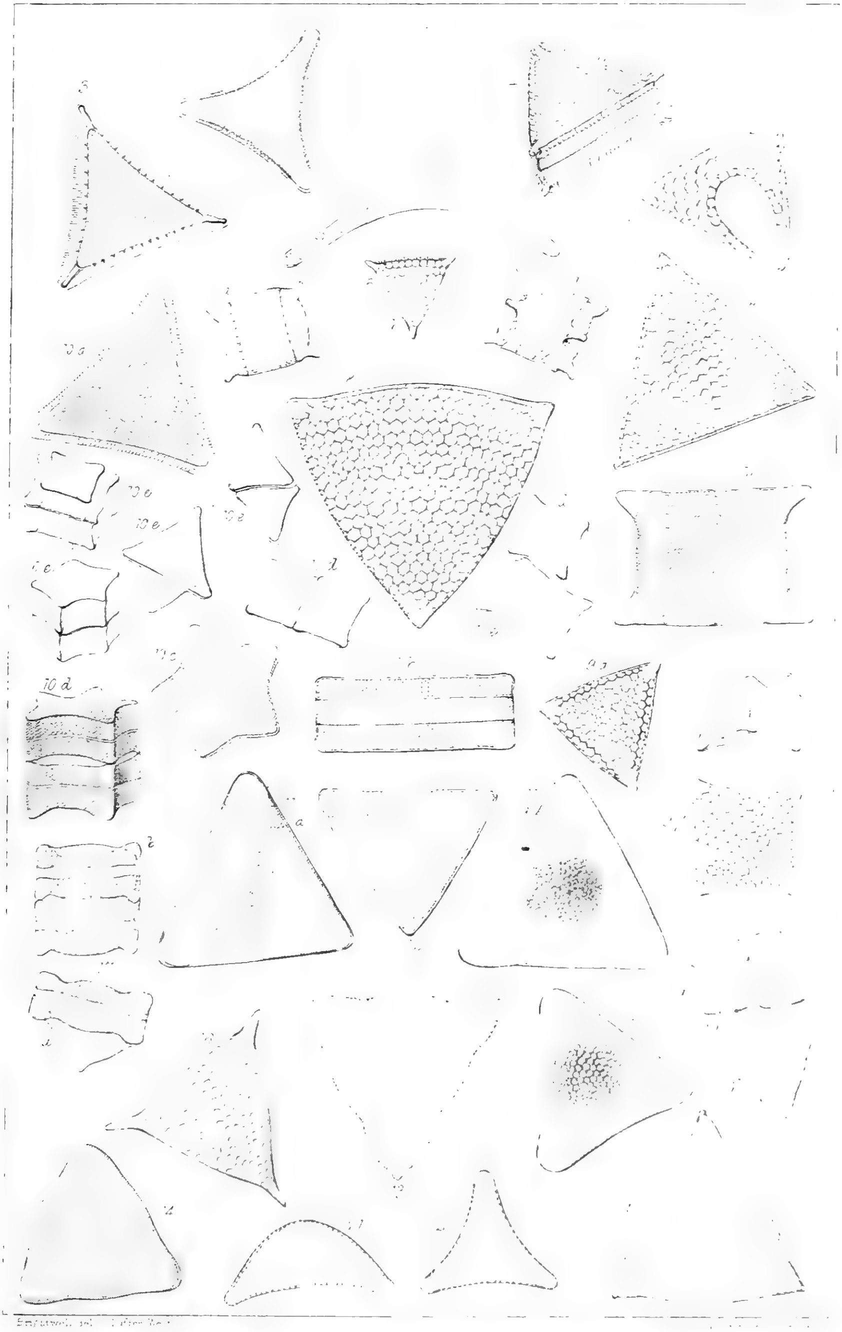

8
10a
10e
10e
10e
10d
10d
10c
11
a
2
14
13

DESCRIPTION OF PLATE V.

Fig.

1. Longitudinal section of superior canine tooth, exhibiting contour markings — their general arrangement. *Slightly magnified.*
2. Transverse section of canine tooth, decalcified and picked abroad, so as to exhibit the annular (stratified) arrangement. *Mag.* 15 *diameters.*
3. Transverse section of canine tooth, exhibiting globular patch, and the various forms of interglobular spaces. *Mag.* 200 *diam.*
4. Innermost film of calcifying dentine, removed from the inner surface of the pulp cavity of a molar, exhibiting calcified globules, and interglobular uncalcified dentine, dried up. The specimen is mounted in balsam. *Mag.* 200 *diam.*
5. Similar to the last, from a bicuspid. This specimen exhibits the calcification of tubeless dentine. *Mag.* 200.

DESCRIPTION OF PLATE VI.

Fig.

1 Represents a section of a portion of the scalp made perpendicular to the surface and parallel to the hairs.

a_1 a_2 a_3 . . . a_6 are muscles attached to the hair-follicles *b b b* . . . . just below the sebaceous glands *c c c* . . . . and extending up towards the epidermis, of which *d* is the corneous and *e* the mucous layer; *f f* is adipose tissue.

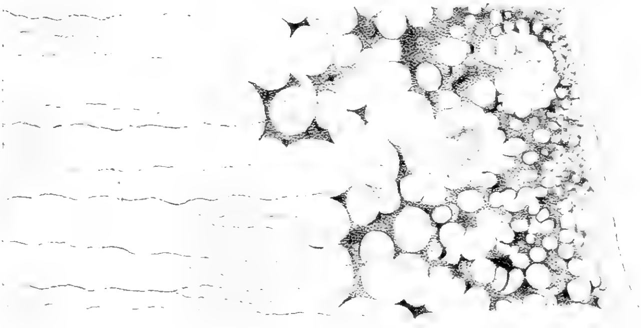
2 Exhibits on a larger scale the upper attachment of the two muscles *a* and a_2 of fig. 1, *a* being the upper end of a_1, and *b* that of a_2; *c* is the corneous and *d* the mucous layer of the epidermis.

3 Shows the insertion of the muscle a_1 of fig. 1 into its hair-follicle, a^1 being the lower end of a_1: the hair and follicle are cut across very obliquely; *b* is the hair slightly tilted out of the inner root-sheath *c*, and dimly seen below through the transparent root-sheath in its course downwards; *d* is the outer root-sheath, *e* the "structureless layer of the hair-follicle," *f* the circular coat of Kölliker, *g* the longitudinal layer, *h* is part of a sebaceous follicle, *i* is some of the fibrous tissue of the dermis.

4 Represents the upper termination of a muscle *b c* with the surrounding fibrous tissue of the scalp gelatinized by acetic acid; *a b* is the free surface deprived of epithelium.

5 Exhibits characteristic nuclei, highly magnified, from a muscle connected with a hair-follicle of the pubes.

6 Shows the appearance of a portion of a muscular fasciculus, from the areola mammæ, after the addition of acetic acid; the rod-shaped nuclei are seen to lie in an indistinctly fibrous stroma.



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Salter del. Tuffen West sc.

TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY

OF

LONDON.

NEW SERIES.

VOLUME I.

LONDON:
SAMUEL HIGHLEY, 32, FLEET STREET.
1853.

LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

INDEX TO TRANSACTIONS.

VOLUME I.

TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY

OF

LONDON.

LACINULARIA SOCIALIS. *A Contribution to the Anatomy and Physiology of the* ROTIFERA. By T. H. HUXLEY, Esq., F.R.S., Assist.-Surgeon R.N. (Read Dec. 31, 1851.)

THE leaves of the *Ceratophyllum*, which abounds in the river Medway, a little above Farleigh Bridge, are beset with small transparent, gelatinous-looking, globular bodies, about 1-5th of an inch in diameter. These are aggregations of a very singular and beautiful Rotifer, the *Lacinularia socialis* of Ehrenberg. On account of their relatively large size, their transparency, and their fixity, they present especial advantages for microscopic observation; and I therefore gladly availed myself of a short stay in that part of the country to inquire somewhat minutely into their structure, in the hope of being able to throw some light on the many doubtful or disputed points of the organization of the class to which they belong.

We are told by Ehrenberg ('Infusions-Thierchen,' p. 403) that *Lacinularia socialis* was discovered and described anonymously in Berlin in 1753. Müller bestowed upon it the name of *Vorticella socialis*, which was changed by Schweigger to *Lacinularia* in 1820. Previously to the time of Ehrenberg the genus appears to have become confounded with *Megalotrocha;* and indeed Dujardin very reasonably, as it seems, altogether denies the propriety of their separation. The extreme resemblance of the two forms is admitted by Ehrenberg himself; but he considers the attachment of the ova of *Megalotrocha* by a filament to the body—a circumstance which does not obtain in *Lacinularia*—and the existence of a gelatinous investment in the latter which is not found in the former, to be sufficient grounds of distinction.

The matter is not one of much importance, but I call attention to the close alliance between *Megalotrocha* and *Lacinularia* for a reason which will appear in the sequel.

The globular aggregations of which I have spoken are not ramified animals like the freshwater Polyzoa, to which, at first sight, they have no small resemblance, but may be truly called compound animals, since each of the *Lacinulariæ* is a separate individual, which at one time swam about freely by itself,* which has voluntarily united itself with its fellows, and has taken its share in throwing out the gelatinous substance which connects them into a whole.

Each *Lacinularia* (Pl. I. fig. 1) has an elongated conical body, whose outer extremity is considerably the wider, and whose inner smaller end is truncated, and serves as a sucker or means of attachment to the stem on which the whole mass is seated; the outer third or fourth of the body contains the viscera, nothing but the muscular cords extending into the inner narrow elongated part of the animal. During contraction the latter portion is thrown into sharp folds, while the visceral portion presents only three or four faint transverse constrictions.

When the Rotifer is in a state of expansion and activity, its outer extremity is terminated by a large horseshoe-shaped wheel-organ, or "trochal disc" (figs. 2, 3), connected with the body by a narrowed neck. When contracted and at rest, the whole of this apparatus is drawn in, and the body takes on a more pyriform appearance (fig. 5).

The mouth lies in the notch of the trochal disc (fig. 4 *d*); the anus is placed on the opposite side, at the lower part of the visceral portion of the animal (*k*).

Anatomy of Lacinularia.—I will now proceed to describe the various organs of the animal more minutely.

The "trochal disc" is, as I have said, wide and horseshoe-shaped. It is seen in profile at figs. 1 and 2; from above at fig. 3. Its edges are richly beset with large cilia, which present a very beautiful wheel-like movement.

Ehrenberg says that the ciliary organ is "as in *Megalotrocha*," and in this he describes the disc as having a simple ciliated edge. I have not examined *Megalotrocha*, but I can say most decidedly that such is not the structure of *Lacinularia*.†

In fact, the edge of the disc has a considerable thickness, and presents two always distinct margins—an upper (*p*) and

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* Or rather had the power of swimming about freely; for it does not appear that the young *Lacinulariæ* ever do leave the gelatinous envelope of the parent mass, unless aggregated together.

† Leydig (Zur Anatomie und Entwickelungs-geschichte der *Lacinularia socialis*—Siebold and Kölliker's Zeitschrift for February, 1852) says that "an elevated ridge runs along the lower surface of the wheel organ, not far from and parallel to its margin, whence there is a double edge and a groove, in which alone ciliary motion is observed."

a lower (p'), of which the former is the thicker and extends beyond the latter.

The large cilia are entirely confined to the upper margin, and, seated upon it, they form a continuous horseshoe-shaped band, which, upon the oral side, passes entirely above the mouth (fig. 4). The lower margin (p') is smaller and less defined than the upper, its cilia are fine and small, not more than 1-4th the size of those of the upper margin. On the oral side this lower band of cilia forms a V-shaped loop (fig. 4), which constitutes the lower and lateral margins of the oral aperture. About the middle of this margin, on each side, there is a small prominence, from which a lateral ciliated arch runs upwards into the buccal cavity, and, below, becomes lost in the cilia of the pharynx.

The aperture of the mouth therefore lies between the upper and lower ciliary bands. It is vertically elongated, and leads into a buccal cavity with two lateral pouches, which give it an obcordate form; these lateral pouches contain the lateral ciliated arches. A narrow pharynx leads horizontally backwards from the lower part of the buccal cavity, and becomes suddenly widened to enclose the pharyngeal bulb in which the teeth are set. Where the buccal cavity meets the pharynx, a sharp line of demarcation exists (fig. 2). In *Melicerta* two curved lines are seen in a corresponding position, and evidently indicate two folds (Pl. II. fig. 26), projecting upwards into the œsophagus. In *Brachionus* these folds are stronger (fig. 31), while in *Stephanoceros* and *Floscularia* this partition between the œsophagus and what may be called the crop is still more marked. From the inner margin of the aperture in the partition two delicate membranes hang down into the cavity of the crop, which have a wavy motion, and it is to them I think that what Mr. Gosse describes as an appearance of "water constantly percolating into the alimentary canal" is due. Dujardin had already noticed (l. c., p. 98) these "vibrating membranes" in *Floscularia* ('Infusoires,' p. 611).

Between the pharyngeal bulb and the mouth there lies on each side of the pharynx a clear, yellowish, horny-looking mass (f), which sometimes appears merely cordate, at others more or less completely composed of two lobes. A similar structure exists in *Brachionus* and *Melicerta*. I believe its function is to give strength to the delicate walls of the pharynx, and that it is therefore to be considered as a part of the horny skeleton.*

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* Leydig (loc. cit.) calls these bodies sacs, and considers them to be salivary glands.

The general nature of the pharyngeal bulb and of its movements has been so often described that it is needless for me to refer to the subject here. With regard to the teeth, however, what I have seen is considerably at variance with the accounts of both Ehrenberg and Dujardin; the former calls the teeth of *Lacinularia* "reihenzähnigen," that is, having a stirrup-like frame, with many teeth set upon it; and the latter, in his general definition of the "Melicertiens," under which head he places *Lacinularia*, has "mâchoires en étrier" ('Hist. Nat. des Infusoires,' p. 612).*

As I have seen it (fig. 6), the armature of the pharyngeal bulb in this species—as in *Stephanoceros*—is composed of four separate pieces. Two of these (which form the incus of Mr. Gosse) are elongated triangular prisms,† applied together by their flat inner faces; the upper faces are rather concave, while the outer faces are convex, and upon these the two other pieces (the mallei of Mr. Gosse) are articulated. These last are elongated—concave internally, convex externally—and present two clear spaces in their interior; from their inner surface a thin curved plate projects inwards. At its anterior extremity this plate is brownish, and divided into five or six hard teeth, with slightly enlarged extremities. Posteriorly the divisions become less and less distinct, and the plate takes quite the appearance of the rest of the piece.

This is essentially the same structure as that of the teeth of *Notommata*, described by Mr. Dalrymple ('Phil. Trans,' 1849), and by Mr. Gosse (on the Anatomy of *Notommata aurita*, Mic. Trans. 1851), and very different from the true "stirrup-shaped" armature.

A narrow œsophagus passes directly downwards from the posterior part of the cavity of the pharyngeal bulb, through the neck of the animal to the body, where it opens into the wide alimentary canal.

This is divided into three portions by an upper, a middle, and a lower constriction.

The two upper parts are often not very distinctly divided. A wide oval or pyriform sac, whose wall contains many nucleated cells, opens into the upper portion on each side. This is the "pancreatic" sac of Ehrenberg.‡

The middle dilatation frequently gives origin to several short cellular cœca.

The lowest dilatation is globular, and has also several cel-

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* Leydig also finds Ehrenberg's figures "untrue to nature."

† Not described by Leydig.

‡ According to Leydig there are four of these bodies, two smaller and two larger, and they do not open into the alimentary canal.—Loc. cit., p. 463.

lular cœca projecting from its outer surface. Within it is clothed with very long cilia.

The intestine is short and wide, and comparatively delicate; it bends suddenly upwards on the side opposite the mouth, and terminates in a cleft of the integument, whose whole extent it did not seem to me to occupy. (Fig. 1 *k*)

The Water Vascular System.—This system is thus loosely and confusedly alluded to—I cannot call it described—by Professor Ehrenberg:*—"The vascular system consists of transverse circular canals in the body, a vascular network at the base of the wheel-organ, with perhaps a broad circular canal at this part, and of trembling gill-like bodies"—(loc. cit., p. 403). The vascular system is so obvious,† that it is difficult to understand how it can have been thus blurred over.

The reader will bear in mind that the two bands which run up from the cloaca in many Rotifera, and are usually connected at their extremity with a "contractile vesicle," while they give attachment in their length to the "trembling gill-like organs" of Ehrenberg, are considered by the latter to be the testes. He says that "the trembling organs" appear to be within the sac in *Hydatina,* outside it in *Notommata.*

Von Siebold ('Vergleichende Anatomie') first pointed out that a vessel runs up in each of these bands, and that the "trembling organs" are short branches of these vessels, each of which contains a vibrating ciliary band (Flimmer-läppchen), to which the trembling appearance is due. According to Von Siebold each of these vibrating bodies indicates an opening in the vessel.

Oskar Schmidt ('Versuch einer Darstellung d. Organisation d. Räderthiere'—Erichsons Archiv, 1846) asserts that the ends of the water-vessels are closed, and that the vibrating body is within them.

Dalrymple (loc. cit.) saw no testes in the lateral bands of *Notommata,* and considers that the "tags" (the "trembling organs" of Ehrenberg) are externally ciliated at their extremities.

Mr. Gosse ('Microscopical Transactions,' 1851) describes the water-vascular system in *Notommata aurita,* and states that the "tags" of Ehrenberg are really pyriform sacs; but he seems not to have distinguished the contained cilium, at least his description is ambiguous. "When trembling moderately they are seen to be little oval bags attached to the tortuous vessel by a neck and sac at the other end. A spiral

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* "I can thus affirm, that what Ehrenberg describes as vessels in Lacinularia are in fact not vessels at all."—*Leydig,* loc. cit., p. 463.

† "Sehr aus-geprägt," Leydig, p. 465.

vessel, closed at the extremity, runs through most of its length, which maintains a wavy motion"—p. 98.[*]

The following is what I have seen in *Lacinularia*:—There is no contractile sac opening into the cloaca as in other genera, but two very delicate vessels, about 1-4000th of an inch in diameter, clear and colourless (fig. 3 *m*), arise by a common origin upon the dorsal side of the intestine. Whether they open into this, or have a distinct external duct, I cannot say.

The vessels separate, and one runs up on each side of the body towards its oral side (fig. 2). Arrived at the level of the pharyngeal bulb, each vessel divides into three branches (fig. 3); one passes over the pharynx and in front of the pharyngeal bulb, and unites with its fellow of the opposite side, while the other two pass, one inwards and the other outwards, in the space between the two layers of the trochal disc, and there terminate as cœca. Besides these there sometimes seemed to be another branch, just below the pancreatic sacs.

A vibratile body was contained in each of the cœcal branches; and there was one on each side in the transverse connecting branch. Two more were contained in each lateral main trunk, one opposite the pancreatic sacs, and one lower down, making in all five on each side.

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[*] M. Udekem (Annales des Sciences, 1851) has given a very elaborate, but I think not altogether correct, account of the water-vascular system of *Lacinularia*. He says that a vascular net-work exists at the base of the lobes of the wheel-organ; that these unite into gland-like ganglia (my "vacuolar thickenings," in the margin of the disc infra); that from these, vessels proceed to the central glands (vacuolar substance, in which the "band" of the water-vascular system terminates, *mihi*), from which three great vessels are given off. Of these, one "passes above the digestive tube, and anastomoses with its fellow from the opposite ganglion; the second presents the same disposition as the first, but is placed below the digestive tube; the third passes directly downwards, skirting the digestive tube." M. Udekem found it "impossible to trace it any further, but considers that it becomes lost on the digestive canal and ovaries." He, therefore, has missed the external opening of the water-vascular system.

What I have seen and described as "vacuolar thickenings" in the peduncle, are described by M. Udekem as vascular ganglia, from which anastomosing vessels proceed.

As M. Udekem's instrument does not seem to have been good enough to define the vibratile cilium—for he speaks only of a "vibratile or trembling movement"—I venture to think that he has been misled in describing these threads and vacuolar thickenings as forming any part of the true vascular system.

Leydig's opinion of M. Udekem's results is, I find, much the same as my own. He says, "Critically considered, then, we find that Udekem's vascular system in Lacinularia is compounded of a multitude of the most heterogeneous parts of the animal—of structures which belong to the most different systems of organs, without one being a true blood-vessel."—L. c., p. 465.

Each of these bodies was a long cilium (1-1400th of an inch), attached by one extremity to the side of the vessel, and by the other vibrating with a quick undulatory motion in its cavity (fig. 8). As Siebold remarks, it gives rise to an appearance singularly like that of a flickering flame.

I particularly endeavoured to find any appearance of an opening near the vibratile cilium, but never succeeded, and several times I thought I could distinctly observe that no such aperture existed. Animals that have been kept for some days in a limited amount of water are especially fit for these researches. They seem to become, in a manner, dropsical, and the water-vessels partake in the general dilatation.

The "band" (fig. 7) which accompanies the vessel appeared to me to consist merely of contractile substance, and to serve as a mechanical support to the vessel. It terminates above, in a mass of similar substance, containing vacuolæ, attached to the upper plate of the trochal disc. I shall refer to this and similar structures below.

I examined these structures so frequently that I have no doubt that the account I have given is essentially accurate,* and I am strengthened in this opinion by the account and figure of the corresponding vessels in *Mesostomum* given by Dr. Max Schulze, in his very beautiful monograph upon the *Turbellaria* (Beiträge zur Naturgeschichte d. Turbellarien). Through these the transition to the richly ciliated water-vessels of the Naidæ, &c., is easy enough.

Vacuolar Thickenings.—(figs. 2, 3 *r*). Under this head I include a series of structures of, as I believe, precisely similar nature, which, on Professor Ehrenberg's principles of interpretation, have done duty as ganglia, testes, &c., in short, have taken the place of any organ that happened to be missing.

In various parts of the body the parietes have become locally thickened, and the prominences thus formed have

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* Leydig's careful description coincides in all essential points with that given above. He particularly notices the fitness of Lacinulariæ that have been imprisoned for some time, for the examination of the water-vascular system.

The only discrepancy of importance in Leydig's account is—firstly, that he considers what I have called the "vacuolar thickening on each side of the pharyngeal mass," and what Ehrenberg calls a nervous centre, to be formed by convolutions of the water-vessel itself; and secondly, that he describes a cloacal vesicle as in other Rotifera. I looked particularly for such a vesicle, but could never see any; in some cases, indeed, I could trace the water-vessels distinct from one another, close to the anus.

Beyond these particular cases, however, I will by no means venture to contradict so accurate an observer as M. Leydig.

Leydig does not seem to have noticed the transverse anastomosing vessel over the pharynx.

developed many clear spaces, or vacuolæ—a histological process of very common occurrence among the lower invertebrata.

Now these thickenings are especially obvious in two localities—1st, in the prolongation of the body below the visceral cavity;* and 2ndly, in the trochal disc.

Of the former thickenings, the four uppermost are promoted by Professor Ehrenberg to be testes, for no other reason, apparently, than that, having missed the true water-vascular system with its bands, he knew not where else to find what he calls a male organ.

Again, the thickenings (figs. 2, 3 *r*) in the trochal disc are mostly towards its lower surface and at its inferior margin; they are generally four or five on each side, and are connected by branched filaments with that body on each side of the pharyngeal mass in which the band of the water-vascular system terminates.

According to Professor Ehrenberg these are all ganglia, and the two yellowish bilobed or cordate bodies on each side of the pharynx are "comparable to a brain!"

Nervous System and Organs of Sense.†—On the oral side

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* Leydig (loc. cit., p. 467-8) regards the central vacuolar mass at the root of the tail as a peculiar gland, from which he says a duct runs downwards to terminate at the extremity of the tail. The purpose of this organ is to secrete the gelatinous envelope. I must confess that I saw no grounds for this interpretation. The extremity of the tail always seemed to me to present a ciliated hemispherical cavity, closed above.

† Leydig (l. c., p. 457 et seq.) criticises at length, and altogether repudiates, the mythical nerves and ganglions which Professor Ehrenberg has ascribed to *Lacinularia*. He does not appear to have seen either the ciliated cavity, or the body which I still venture to think is the only true ganglion; but describes a very peculiar nervous system, consisting of—

1. A ganglion behind the pharynx, composed of four bipolar cells, with their processes.

2. A ganglion at the beginning of the caudal prolongation, similarly composed of four larger ganglionic cells and their processes.

The latter cells are what I have described as vacuolar thickenings; I could find no difference whatever between them and the thickenings in the disc, which Leydig allows to be mere thickenings.

The former were not observed by me. I have not been able to repeat my investigations upon this point, as I hope to do; for the present I must offer as arguments against Leydig's interpretation of the nature of the structures which he observed—

1st. That the body which I describe as a ganglion is perfectly similar in appearance to the mass on which the eye-spots of *Brachionus* are seated.

2nd. That if such an arrangement of the nervous system as that which Leydig describes exists, the Rotifera are very widely different from their congeners, and, indeed, from all known animals.

Leydig himself, however, says,—"That these cells, with their radiating processes, are ganglion-globules and nerves, is a conclusion drawn simply from the histological constitution of the parts, and from the impossibility of making anything else out of them, unless, indeed, organs are to be named according to our mere will and pleasure."—L. c., p. 459.

of the neck of the animal, or rather upon the under surface of the trochal disc, just where it joins the neck, and therefore behind and below the mouth, there is a small hemispherical cavity (fig. 4 *o*) (about 1-1400th of an inch in diameter), which seems to have a thickened wall, and is richly ciliated within. Below this sac, but in contact with it by its upper edge, is a bilobed homogeneous mass (figs. 2 and 4 *n*) (about 1-800th of an inch in diameter), resembling in appearance the ganglion of Brachionus, and running into two prolongations below, but whether these were continued into cords or not I could not make out.

I believe that this is, in fact, the true nervous centre, and that the sac in connection with it is analogous to the ciliated pits on the sides of the head of the Nemertidæ, to the "ciliated sac" of the Ascidians, which is similarly connected with their nervous centre, and to the ciliated sac which forms the olfactory organ of *Amphioxus.*

Mr. Gosse has described a similar organ in *Melicerta ringens*, and I have had an opportunity of verifying his observations, with the exception of one point. According to this observer, the cilia are continuous from the trochal disc into the cup; so far as I have observed, however—and I paid particular attention to the point—the cilia of the cup are wholly distinct from those of the disc.

The interesting observations of the same careful observer upon the architectural habits of *Melicerta* would seem to throw a doubt upon the propriety of ascribing to the organ in question any sensorial function.

But however remarkable it may seem that an animal should build its house with its nose, we must remember that a similar combination of functions is obvious enough in the elephant.

No eyespots exist in the adult *Lacinularia.* In the young there are two red spots on the upper surface of the trochal disc, which are stated by Professor Ehrenberg to be seated upon "medullary masses" (Mark-Knötchen). I could not satisfy myself either of the truth of this statement or the contrary, in consequence of the difficulty of distinguishing the separate tissues in the young animal.

I may be permitted here to say a word upon the nature of the "calcar" or "respiratory tube" of Ehrenberg, which exists in so many Rotifera. For his first notion, that it is connected with the reproductive system, Professor Ehrenberg has substituted the idea that it is a respiratory tube, through which currents of water are conducted into the cavity of the body, and bathe the "trembling organs" which he calls "gills." Professor Ehrenberg, however, has not produced any evidence of such in-going currents, and Dujardin has denied their existence. So far as has yet been observed, the calcar is in immediate connection with the nervous ganglion. *Melicerta* affords a very good opportunity for examining the structure of the organs, of which in this genus there are two. It is a somewhat conical process of the integument, containing a similar process of the internal membrane. This, however, stops short a little distance from the extremity, and forms a transverse diaphragm, from the centre of which a bunch of long and excessively delicate setæ proceeds (fig. 29). I could observe no trace of any aperture with a power of 600 diam., though of course this is merely negative evidence.

Is it not possible that, as the "ciliated sac" of the Ascidians has its analogue in the "fossa" of the Rotifera, so the calcar may answer to the "languet," which has a similar relation to both sac and ganglion?

In *Notommata* there is no calcar, but nervous cords proceed from the ganglion to the ciliated spots about the middle of the dorsal surface (Dalrymple).

Reproductive Organs.—Considering Professor Ehrenberg's determination of the male organs to be set aside, his description of the reproductive organs extends only to the ovary, which, he says, in *Lacinularia* "lies in the posterior cavity of the body, and has thus one and the same outlet with the intestine" (p. 403). This seems to imply an oviduct; I could, however, see no such organ.* The ovary consists of a pale, slightly granular mass of a transversely elongated form (fig. 5 *l*), and somewhat bent round the intestine; it is enclosed within a delicate transparent membrane, which is hardly visible in the unaltered state, but becomes very obvious by the action of acetic acid, which contracts the substance of the ovary and throws the membrane into sharp folds.

Pale clear spaces, which sometimes seem to be limited by a distinct membrane, are scattered through the substance of the ovary, and in each of these a pale circular nucleus is contained. The nucleus is more or less opaque, but usually contains 1-3 clear spots (fig. 9).

These are the germinal vesicles and spots of the future ova. Acetic acid, in contracting the pale substance, groups it round these vesicles, without, however, breaking it up into separate masses. It renders the nuclei more evident.

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* Leydig (l. c., p. 469) says that there is a wide oviduct which becomes folded when empty. I must leave the discrepancy until a further examination decides which is right.

The ova are developed thus:—One of the vesicles increases in size, and reddish elementary granules appear in the homogeneous substance round it (fig. 10). This accumulation increases until the ovum stands out from the surface of the ovary; but invested by its membrane which, as the ovum becomes pinched off as it were, takes the place of a vitellary membrane.

In the mean while the germinal vesicle has increased in size, and its nucleus is no longer visible. In the ovum it appears as a clear space; isolated by crushing the ovum it is a transparent, colourless vesicle.

The perfect ova are oval, about 1-10th inch in diameter, and are extruded by the parent into the gelatinous connecting substance, where they undergo their development (fig. 11).

The changes which take place after extrusion, or even to some extent within the parent, are—1, the disappearance of the germinal vesicle (as I judge from one or two ova in which I could find none); 2, the total division of the yolk, as described by Kölliker in *Megalotrocha*, until the embryo is a mere mass of cells, from which the various organs of the fœtus are developed (figs. 12, 13, 14, 15, 16).

The youngest fœtuses are about 1-70th of an inch in length. The head is abruptly truncated, and separated by a constriction from the body: a sudden narrowing separates the other extremity of the body from the peduncle, which is exceedingly short and provided with a ciliated cavity, a sort of sucker, at its extremity. The head is nearly circular, seen from above, and presents a central protuberance in which the two eyespots are situated. The margins of this protuberance are provided with long cilia—it will become the upper circlet of cilia in the adult.

The margin of the head projects beyond this, and is fringed with a circlet of shorter cilia; this is the rudiment of the lower circlet of cilia in the adult. The internal organs are perceived with difficulty; but the three divisions of the alimentary canal, which is as yet straight and terminates in a transparent cloaca, may be readily made out. The water-vascular canals cannot be seen, but their presence is indicated by the movement of their contained cilia here and there (fig. 17).

In young *Lacinulariæ*, 1-30th of an inch in length, the head has become triangular, the peduncle is much elongated, and thus it gradually takes on the perfect form (fig. 18). The young had previously crept about in the gelatinous investment of the parents; they now begin to "swarm," uniting together by their caudal extremities, and are readily pressed out as united free swimming colonies, resembling, in this state, the genus *Conochilus*.

The process of development of these ova is therefore exactly that which takes place in all fecundated ova, and would lead one to suspect that spermatozoa should be found somewhere or other.

Now, from the observations of Mr. Dalrymple, we should be led to seek a distinct male form with the ordinary spermatozoa. From those of Kölliker, on the other hand, we should equally expect to find each individual a hermaphrodite, with the very peculiar spermatozoon-like bodies which he has described in *Megalotrocha*.

I must have examined some scores of individuals of Lacinularia with reference to the former case, without ever finding a trace of a male individual. All were similar, all contained either ova or ovarium, nowhere was an ordinary spermatozoon to be seen. On the other hand, I found in many individuals singular bodies, which answered precisely to Kölliker's description of the "spermatozoa" of *Megalotrocha*. They had a pyriform head about 1-1000th in. in diam. (fig. 19), by which they were attached to the parietes of the body, and an appendage four times as long, which underwent the most extraordinary contortions, resembling however a vibrating membrane much more than the tail of a spermatozoon; as the undulating motion appeared to take place in only one side of the appendage, which was zigzagged, while the other remained smooth.

According to Kölliker again, these bodies are found only in those animals which possess ova undergoing the process of yolk division, while I found them as frequently in those young forms which had not yet developed ova, but only possessed an ovary.

Are these bodies spermatozoa?* Against this view we have

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* Leydig (loc. cit., p. 474) has observed, in several cases, what I describe as probable spermatozoa, but considers them to be parasites.

He does not notice the similarity of these bodies to those described by Kölliker in *Megalotrocha*; but thinks that the latter has been misled by the vibratile organs.

Leydig does not appear to be acquainted with the important observations of Dalrymple, Brightwick, and Gosse; but brings forward as the true spermatozoon a *tertium quid*, whose description I subjoin in his own words:—"In almost every colony we meet with from one to four (in large colonies) individuals which are distinguishable from the rest at the first glance. By reflected light they appear quite white, which appearance arises from peculiar corpuscles which fill the cavity of the body more or less completely, and are driven hither and thither by the contractions of the animal, as well into the wheel-organ as into the caudal appendage. They are yellowish globular bodies, with sharp contours, 1-5000th to 1-1700th of an inch in diameter, with a double centre and a lighter periphery. The surface is covered by a mesh-work of bands projecting in-the unquestionable separation of the sexes in *Notommata*, and the very great difference between these and the spermatozoa of *Notommata.* Neither are the mode of development nor the changes undergone by the ovum any certain test that it requires or has suffered fecundation, inasmuch as the process closely resembles the original development of the aphides (*see* Leydig, Siebold and Kölliker, Zeitschrift, 1850).

In the view that Kölliker's bodies are true spermatozoa, it might be said—1. That the sexes are united in most Distomata, for instance, and separated in species closely allied (*e.g. D. Okenii*).

2. That the differences between these bodies and the spermatozoa of *Notommata* is not greater than the difference between those of *Triton* and those of *Rana.*

3. That their development from nucleated cells within the body of *Megalotrocha* (teste Kölliker) is strong evidence as to their having *some* function to perform; and it is difficult to imagine what that can be if it be not that of spermatozoa. However, it seems to me impossible to come to any definite conclusion upon the subject at present.*

Kölliker supposes that Ehrenberg has seen the "spermatozoa" and has taken them for the "long vibratile bodies;" while Siebold imagines that Kölliker has taken the long vibrating bodies for spermatozoa. No one, however, who has seen both structures can be in any danger of confounding the one with the other.

A sexual propagation of Lacinularia.—Whatever may be the nature of the process of reproduction just described, there exists another among the Rotifera, which has been noticed by almost every one, but not hitherto distinguished or understood. This is the production of the so-called "winter ova," but which from their analogy with what occurs in *Daphnia*, I prefer to call "ephippial ova."

Ehrenberg says that many ova of *Hydatina* have a double shell, and between the two shells there is a wide space. "Similar ones occur in many *Rotifera*, in various often irregular forms: these have a much slower development, and I call them thence winter ova" (p. 413). See also his account of *Brachionus urceolaris* (p. 512). He does not notice the occurrence of these ova in *Lacinularia* or *Megalotrocha.*

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ternally, which give the body a mosaic (parquettirtes) appearance. Immoveable hairs, 1-1700th of an inch long, may be seen in isolated globules to radiate from the surface."

I have not observed any of these bodies.

* I may mention here that I have found in *Melicerta* an oval sac lying below the ovary, and containing a number of strongly-refracting particles closely resembling in size and form the heads of the spermatozoa of *Lacinularia.*

Kölliker speaks of the ova of *Megalotrocha* acquiring a deep yellow investment, as if it were a further development of those ova whose yolk he saw divided. I am strongly inclined to believe, however, that he was misled by the peculiar appearance of the winter ova, which look as if they had undergone yolk division.

Dalrymple gives a lengthened account of these peculiar ova in *Notommata.* He says that they are dark, and that their outer covering appears to consist of an aggregation of cells, under which is a second layer of cells containing pigment molecules. No distinct germinal vesicle, he says, is to be found in these ova "from the want of general transparency" (loc. cit., p. 340).

It will be observed that all these authors consider the winter ova or ephippial ova and the ordinary ova to be essentially *identical*, only that the former have an outer case. The truth is, that they are essentially *different* structures. The true ova are single cells which have undergone a special development. The ephippial ova are aggregations of cells (in fact, larger or smaller portions—sometimes the whole—of the ovary), which become enveloped in a shell and simulate true ova.

In a fully grown *Lacinularia* which has produced ova, the ovary, or a large portion of it, begins to assume a blackish tint (fig. 20); the cells with their nuclei undergo no change, but a deposit of strongly refracting elementary granules takes place in the pale connecting substance. Every transition may be traced from deep black portions to unaltered spots of the ovarium, and pressure always renders the cells with their nuclei visible among the granules. The investing membrane of the ovary becomes separated from the dark mass so as to leave a space, and the outer surface of the mass invests itself with a thick reddish membrane (fig. 21), which is tough, elastic, and reticulated from the presence of many minute apertures. This membrane is soluble in both hot nitric acid and caustic potass.*

The nuclei and cells, or rather the clear spaces indicating them, are still visible upon pressure, and may be readily seen by bursting the outer coat.

By degrees the ephippial ovum becomes lighter, until at last its colour is reddish brown, like that of the ordinary ova; but its contents are now seen to be divided into two masses—hemispherical from mutual contact (fig. 22). If this body be now crushed, it will be found that an inner structureless membrane exists within the fenestrated membrane, and sends a partition

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* Leydig (l. c., p. 453) says that the shells of the ova were not dissolved by maceration in a solution of caustic soda (cold?) for twenty-four hours, and thence concludes that they may be composed of chitin.

The above observation tends to the contrary conclusion.

inwards, at the line of demarcation of the two masses (fig. 23). The contents are precisely the same as before, viz., nuclei and elementary granules (fig. 24). This, indeed, may be seen through the shell without crushing the case.

I was unable to trace the development of these ephippial ova any further. Those of *Notommata*, it appears, lasted for some months without change (Dalrymple).

It is remarkable that in Lacinularia these bodies eventually, like the ephippium of *Daphnia*, contain two ovum-like masses; and there can, I think, be little doubt that the former, like the latter, are subservient to reproduction.

There are then two kinds of reproductive bodies in *Lacinularia:*—

1. Bodies which resemble true ova in their origin and subsequent development, and which possess only a single vitellary membrane.

2. Bodies, half as large again as the foregoing, which resemble the ephippium of *Daphnia;* like it have altogether three investments; and which do not resemble true ova either in their origin or subsequent development; which therefore probably do not require fecundation, and are thence to be considered as a mode of asexual reproduction.*

General Relations of the Rotifera.—It is one of the great blessings and rewards of the study of nature that a minute and laborious investigation of any one form tends to throw a light upon the structure of whole classes of beings. It supplies us with a fulcrum whence the whole zoological universe may be moved. I would illustrate this truth by showing how, in my belief, the structure of *Lacinularia*, as thus set forth, taken in conjunction with some other facts, gives us a clue to the solution of the questio vexata of the zoological position of the Rotifera, and thence to the serial affinities of a large portion of the Invertebrata.

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* Leydig distinguishes particularly between the ordinary, and what I have termed, the ephippial ova.

His description of the latter agrees essentially with that which has been given above; but he has not, I think, observed the genesis of the ephippial ova with sufficient care, and he thence interprets their structure by supposing that they are ordinarily fecundated ova, which have undergone a peculiar method of cleavage. The tendency of the observations detailed above, on the other hand, is to show that they are not ova at all in the proper sense, but peculiar buds like those of *Aphis* or *Gyrodactylus*, and as such are capable of development without fecundation.

In the new edition of Pritchard's 'Infusoria,' it is stated (p. 620), that "in a recent paper by Mr. Howard on this species, he states that there are two kinds of reproductive bodies—one the ordinary ova, the other twice their size, representing gemmæ." No reference is given to Mr. Howard's paper, and I have been at a loss to discover it, though desirous to do justice to him if possible.

The curious analogy in form between the genus *Stephanoceros* and the Polyzoa has, I believe, been the chief consideration which has led many naturalists, both in England and on the Continent, to arrange the Polyzoa and Rotifera together. This has been done in two ways, either by denying the affinity of the Rotifera with the Vermes, and so approximating them to the Polyzoa considered as organized on the molluscous type, or, as Leuckhart has done, by admitting the affinity of the Rotifera with the Vermes, but denying that of the Polyzoa with the Mollusca.

I believe that there is a fundamental error in each case, namely, that of approximating the Polyzoa and the Rotifera at all. The resemblance between *Stephanoceros* and a Polyzoon is very superficial. No Polyzoon has the cilia on its tentacles arranged like those of *Stephanoceros;* nor has any a similarly-armed gizzard: still less is there any trace of the water-vascular system which exists in all Rotifera.

The relations between the Polyzoa and the Rotifera, then, are at the best mere analogies.

On the other hand, the general agreement in structure between the Rotifera and the Annuloida — under which term I include the Annelida, the Echinoderms, Trematoda, Turbellaria, and Nematoidea—is very striking, and such as to constitute an unquestionable affinity.*

The terms of resemblance are these:—

1. Bands of cilia, resembling and performing the functions of the wheel-organs, are found in Annelid, Echinoderm, and Trematode larvæ.

2. A water-vascular system, essentially similar to that of the Rotifera, is found in Monœcious Annelids, in Trematoda, in *Turbellaria*, in Echinoderms, and perhaps in the Nematoidea.†

3. A similar condition of the nervous system is found in *Turbellaria.*

4. A somewhat similarly armed gizzard is found in the Nemertidæ; and the pharyngeal armature of a Nereid larva may well be compared with that of *Albertia.*

5. The intestine undergoes corresponding flexures in the Echinoderm larvæ. There are, therefore, no points of their organization in which the Rotifera differ from the Annuloida;

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* M. Milne Edwards, with his accustomed acuteness, pointed out (Annales des Sciences, 1845) the close affinity of the Rotifera with the Annelids, the Turbellaria, and the Nematoidea; but he did not include the Echinoderms in the group, doubtless because, at the time he wrote, sufficient was not known of the Echinoderm larvæ to demonstrate their truly annuloid nature.

† To these may be added the Cestoidea and the Nemertidæ.

and there is one very characteristic circumstance, the presence of the water-vascular system, in which they agree with them.

Now, with what Annuloida are the Rotifera most closely allied? To determine this point, we must ascertain what is the fundamental type of organization of the Rotifera.

Suppose in *Lacinularia* a line to be drawn from the mouth to the anus, and that this be considered as the axis of the body; suppose, again, that the side on which the ganglion lies is the dorsal side, the opposite being the ventral; suppose, also, the mouth end to be anterior, the anal end posterior,—then it will be found that the lower circlet of cilia upon the trochal disc encircles the axis of the body, while the upper circlet of large cilia does not encircle the axis, but lies in the lower and anterior region of the body.

If the region behind that ciliary circlet which is traversed by the axis be called the post-trochal region, and that in front of it the pre-trochal region, we find that the circlet of large cilia is developed in the inferior pre-trochal region.

Now compare this Rotifer with the larva of an Annelid. It will be immediately seen that the two are of essentially the same type, only that, while the Annelid larva is equally and symmetrically developed in all its regions, and has frequently no accessory ciliated bands, the Rotifer has its superior post-trochal and inferior pre-trochal regions developed in excess; so that the anus is thrown to the ventral, while the mouth is thrust towards the dorsal surface,* an accessory ciliated circlet being at the same time developed in the latter region.

Melicerta ringens (compare figs. 26-28) resembles *Lacinularia* in the arrangement of its ciliated bands, only they are far more distorted from their normal circular form. Tubicolaria closely resembles *Melicerta*, and there can be little doubt that *Megalotrocha* and *Limnias* are to be added to this division.

In *Brachionus*, *Philodina*, *Rotifer*, *Notommata*, the same fundamental type obtains, but the deviation from symmetry takes place in a different way.

In all these it is the ventral post-trochal region which is over-developed, and therefore the anus is thrown to the dorsal or ganglionic side.

In *Notommata* the trocha appears to be simple and unaltered in most species, and there is no accessory circlet.

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* This over-development is not a mere matter of hypothesis. The young *Lacinularia* has the anus nearly terminal, and the "peduncle" only subsequently attains its full proportions. Compare fig. 17 and fig. 18, pl. I.

In *N. aurita*, however, as it appears from Mr. Gosse's description, and in *Brachionus polyacanthus* (figs. 30-33), several processes, three in the latter case, are developed from the superior pre-trochal region. They are richly ciliated, and appear to represent the accessory circlet of *Lacinularia.*

Another distinct type is presented by *Philodina* (figs. 34-37). In this the great trocha is bent upon itself, and the anterior divison of it, at first sight, simulates an accessory circlet developed in the superior pre-trochal region. It is not so, however, as the continuity of the band of cilia can be readily traced throughout.

To this division of the Rotifera, viz. those which have the anus on the same side of the body as the ganglion, appear to belong the genera *Stephanoceros* and *Floscularia*—at least, if the ganglion be what I believe it to be, a granular mass, in connexion with the upper part of a large oval mass composed of clear cells, and having a pit in its centre exteriorly, which I believe to be the altered ciliated sac.

These might then be considered as Notommatæ whose trochal circlet had become produced into long processes in *Stephanoceros*, while they remain as shorter knobs in *Floscularia;* a tendency to which development may be traced in the little processes into which the trochal circlet is thrown around the mouths of *Lacinularia* and *Melicerta*, and perhaps in the three processes which, according to Mr. Dalrymple, arch over the mouth in *Notommata.*

But *Stephanoceros*, *Philodina*, *Notommata*, *Brachionus*, and *Lacinularia* are the types of the great divisions of the Rotifera, and whatever is true of them will probably be found to be true of all the Rotifera.

We may say, therefore, that the Rotifera are organized upon the plan of an Annelid larva, which loses its original symmetry by the unequal development of various regions, and especially by that of the principal ciliated circlet or trochal band; and it is curious to remark that, so far as the sexes of the Rotifera can be considered to be made out (approximatively), the diœcious forms belong to the latter of the two modifications of the type which have been described, while the monœcious forms belong to the former.

It is this circumstance which seems to me to throw so clear a light upon the position of the Rotifera in the animal series. In a Report in which I have endeavoured to harmonise the researches of Prof. Müller upon the Echinoderms,* I have shown that the same proposition holds good of the latter in

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* Annals of Natural History, 1851.

their larval state, and hence I do not hesitate to draw the conclusion (which at first sounds somewhat startling) that *the Rotifera are the permanent forms of Echinoderm larvæ*, and hold the same relation to the Echinoderms that the Hydriform Polypi hold to the Medusæ, or that *Appendicularia* holds to the Ascidians.

The larva of *Sipunculus* might be taken for one of the Rotifera; that of *Ophiura* is essentially similar to *Stephanoceros;* that of *Asterias* resembles *Lacinularia* or *Melicerta.* The pre-trochal processes of the Asterid larva *Brachiolaria* are equivalent to those of *Brachionus.*

Again, the larvæ of some Asterid forms and of *Comatula* are as much articulated as any Rotifera.

It must, I think, have struck all who have studied the Echinoderms, that while their higher forms, such as *Echiurus* and *Sipunculus*, tend clearly towards the Diœcious Annelida, the lower extremity of the series seemed to lead no-whither.

Now, if the view I have propounded be correct, the Rotifera furnish this wanting link, and connect the Echinoderms with the Nemertidæ and Nematoid worms.

At the same time it helps to justify that breaking up of the class Radiata of Cuvier, which I have ventured to propose elsewhere, by showing that the Rotifera are not "radiate" animals, but present a modification of the Annulose type—belong, in fact, to what I have called the *Annuloida*, and form the lowest step of the Echinoderm division of that subkingdom.

From our imperfect knowledge of the Nematoid worms it is difficult to form a definite scheme of the affinities of the Annuloida; but perhaps they may be sketched as in the Diagrams, pl. III.

These diagrams represent the arrangement of the ciliated bands with relation to the axis of the body in the Rotifera.

Underneath each Rotifer is an Annelid or Echinoderm larva, with its ciliary bands represented in a like diagrammatic manner, to show the essential correspondence between the two.

This paper is now printed exactly as it was read before the Microscopical Society on the 31st of December, 1851, with the exception of those notes which refer to the very excellent memoir of Dr. Leydig, published in February, 1852. Dr. Leydig must have been working at the subject at about the same time as myself, in the autumn of last year; and if I refer to the respective dates of our communications, it is merely for the purpose of giving the weight of independent observation to those points (and they are the most important) in which we agree.

It is the more necessary to draw attention to this fact, since Professor Ehrenberg, in a late communication to the Berlin Academy, hints that the younger observers of the day are in a state of permanent conspiracy against his views. T. H. H.

July 9, 1852.

On the Structure of the Raphides *of* Cactus enneagonus.

By John Quekett, Esq., Professor of Histology to the Royal College of Surgeons of England. (Read Jan. 28, 1852.)

Every living being that is made up of parts or organs, each having a definite structure, and performing a certain office, is termed an organized being; and the materials, however complicated, of which it is composed, are termed organic matter.

The components of the Mineral Kingdom, on the contrary, possessing little or no structure, but generally being homogeneous throughout, and having no adaptation of parts to perform separate functions, are called inorganic or inorganized.

If organic matter be subjected to chemical analysis, it will be found that in the first stage certain compounds, termed by some chemists proximate principles, or organic compounds or organizable substances by others, will be obtained; each of which principles, by further or ultimate analysis, will yield simple elements. Thus, for instance, from the organized substance termed muscle we obtain by analysis, first, fibrine, a proximate principle, which is its chief constituent; and, subsequently, by the analysis of fibrine, we get the principal elements—oxygen, hydrogen, carbon, nitrogen, and sulphur in certain proportions. If, however, a mineral, or inorganic matter of any kind be subjected to analysis, we get no proximate principles, but only simple elements. Organic matter may be found in two states, viz., in that of life or in that of death. Living matter possesses the powers of growth and integrity, may select from surrounding materials, and appropriate to its uses the inorganic elements; but in the state of death these powers are destroyed, and decay is the natural consequence.

It is to the nature of this organic basis or matter of plants that I would now direct your attention, leaving that of animals for future consideration.

In commencing our examination with the vegetable kingdom we shall find that inorganic or earthy matter exists in plants in two states, viz., 1st, as crystals, termed raphides, occurring in the interior of cells, and 2nd, in intimate connexion with the organic basis of the plant—in this last state the inorganic element chiefly consists of silica.

If we examine a portion of the layers of an onion or of a squill, or by taking a thin section of the stem or root of the garden rhubarb, we shall observe many cells in which either bundles of needle-shaped crystals or masses of a stellate form occur; these are termed raphides, from the Greek Ραφις, a needle, the first crystals discovered being of this shape.

Raphides were first noticed by Malpighi in *Opuntia*, and were subsequently described by Jurine and Raspail.

According to the latter observer the needle-shaped or acicular are composed of phosphate, and the stellate of oxalate of lime. There are others having lime as a basis, combined with tartaric, malic, or citric acid. These are easily destroyed by acetic acid; they are also very soluble in many of the fluids employed in the conservation of objects: some of them are as large as the 1-40th of an inch; others are as small as the 1-1000th. They occur in all parts of the plant—in the stem, bark, leaves, stipules, sepals, petals, fruit, root, and even in the pollen, with few exceptions. They are always situated in the interior of cells, and not, as has been stated by Raspail and others, in the intercellular passages.*

Some of the containing cells become much elongated, but still the cell-wall can be readily traced. In some species of Aloe, as for instance *Aloe verrucosa*, with the naked eye you will be able to discern small silky filaments. When these are magnified they are found to be bundles of the acicular form of raphides. In portions of the cuticle of the medicinal squill—*Scilla maritima*—several large cells may be observed, full of bundles of needle-shaped crystals. These cells, however, do not lie in the same plane as the smaller ones belonging to the cuticle. In the cuticle of an onion every cell is occupied either by an octohedral or a prismatic crystal of oxalate of lime—in some specimens the octohedral form predominates, but in others from the same plant, the crystals may be principally prismatic, and are arranged as if they were beginning to assume a stellate form.

Those persons who are in the habit of examining urinary deposits must be familiar with the appearance of the crystals of oxalate of lime, and would readily recognise their close resemblance to those in the cells of the onion.

Raphides of oxalate of lime are found in very great abundance in the medicinal rhubarb—the best specimens from Turkey containing as much as 35 per cent.; those from the East Indies 25; and the English, or that sold in the streets by men dressed up as Turks, 10 per cent.

Buyers of this drug generally judge of its quality by its grittiness, that is by the quantity of raphides it contains; and this is a curious fact, as the crystalline matter cannot be of any beneficial importance in the action of the medicine, for the

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* As an exception I may state that, many years ago, I discovered them in the interior of the spiral vessels in the stem of the grape-vine; but with some botanists this would not be considered as an exceptional case, the vessels being regarded as elongated cells.

tincture in which no raphides are contained is as efficacious as the powder.

Some plants, as many of the cactus tribe, are made up almost entirely of raphides. In some instances every cell of the cuticle contains a stellate mass of crystals, in others the whole interior is full of them, rendering the plant so exceedingly brittle that the least touch will occasion a fracture, so much so that some specimens of *Cactus senilis*, said to be 1000 years old, which were sent a few years since to Kew from South America, were obliged to be packed in cotton, with all the care of the most delicate jewellery to preserve them during the transport,

Raphides of peculiar figure are common in the bark of many trees. In the hiccory (*Carya alba*) may be observed masses of flattened prisms having both extremities pointed. Similar crystals are present in the bark of the lime-tree; they occur in rows, their pointed extremities nearly touching each other, their principal situation being in the cellular tissue close to the medullary rays. Other forms of crystals, as the rhombohedron and a small stellate form, are also found in the bark of the lime.

In vertical sections of the stem of *Elæagnus angustifolia* numerous raphides of large size may be seen in the pith.

Raphides are also found in the bark of the apple-tree, and in the testa of the seeds of the elm; each cell contains two or more very minute crystals.

It is at present not known what office raphides perform in the economy of the plant: some have gone so far as to state that they are deposits to be applied towards the mineral part or skeleton of the plant; but the fact of their being insoluble in vegetable acids would prove this view of their use to be erroneous. The more rational supposition is, that they are generally accidental deposits formed by the union of vegetable acids with lime or other base existing in the plant or taken up from the soil. They may, however, be formed artificially, and my late brother succeeded in doing so in the following manner:—If oxalic or phosphoric acid be added to lime-water, the precipitate will be pulverulent and opaque. If, however, a vessel containing oxalate of ammonia in solution be connected by means of a few filaments of cotton with another vessel containing lime-water, crystals will be formed at the end of the fibres in contact with the lime-water.

This led him to attempt to form them in the interior of cells: he selected for the purpose a portion of rice paper; this substance was placed in lime-water under an air-pump in order in fill the cells with the fluid; the paper was then dried, and the process again and again repeated, until many of the cells were charged with lime-water; portions of the paper were then placed in weak solutions both of oxalic and phosphoric acid, and at the end of three days crystals were found in the cells in both instances, those of the oxalic acid being of the stellate and those in the phosphoric acid being of the rhombohedral form. None of the acicular, however, were ever present, although the process was continued for ten days. One of these pieces of rice paper I now show you, and a stellate mass of crystals is very plainly to be seen in the centre of the field—each precisely resembles the raphides found in rhubarb.

The above description, which is a modification of that given in my lectures, well applies to the raphides in most plants, but the case will appear to be a little different in those plants, such as the cacti, which live to a great age, and in which the crystalline matter is in the greatest abundance. Whilst working at this subject about twelve months since I was induced to examine the raphides of a species of *Cactus* termed *enneagonus*, a specimen of which had been given me by a friend as abounding in crystals. This specimen I have with me, just as I received it, the part containing the crystals being about thirty-nine years old; that they are very numerous, and at the same time very large, may be known by their being visible to the naked eye. If any of these raphides be examined in fluid with a power of at least 100 diameters, they will appear to be made up of crystals (as far as their external surface is concerned), which project outwards in the form both of sharp pointed and truncated prisms; and if the centre be brought into focus this part will be found more opaque than the rest, and to be of a circular figure like a nucleus. If the masses be mounted in Canada balsam before they are examined they will then present one or other of the appearances given in Plate III. figs. 1, 2, 3, 4; some, as in fig. 1, will show a nucleus surrounded by concentric laminæ of a brown colour; others, as in fig. 2, will exhibit a spot like a nucleus, first surrounded by concentric laminæ, but towards the margin the laminæ become irregular, and the margin itself is composed of prismatic flattened crystals, not clear and transparent, but more or less granular, whilst some other specimens, as shown in figs. 3 and 4, are made up almost entirely of the prismatic crystals, with little or no trace of concentric lamination. Having found this to be the case I was anxious to ascertain the chemical composition of these so-called raphides, and for the purpose I tried the action of various re-agents upon them, and noticed that the crystals were slowly dissolved in dilute hydro-chloric acid, but I was much astonished to find that in many cases a basis or cast of the entire mass was left behind after the action of the acid had ceased; and in most instances I could tell precisely not only the spot where the crystals had been, but also form some general idea of the shape of the mass, and instead of their being, as I first imagined, a mass of crystals only, I found that there was some organic matter or basis connected with them.

When one of these raphides is crushed between two plates of glass, the outer crystals are readily detached; some of these are represented by fig. 6: the part composing the nucleus is much the hardest, and exhibits a radiated and concentric laminated deposit, like the masses of carbonate of lime found in the urine of the horse. If portions of the cellular tissue of the cactus be examined, some cells will occasionally be found in which a more or less spherical mass, as shown in fig. 5, occurs in the centre of each: these masses correspond in every respect with the nuclei of the larger raphides: it would therefore appear that in the early stages of development of these raphides the nucleus consisted of one of these spherical bodies, and the crystals on the exterior were formed subsequently. It may also happen that the bases of some of the crystals in process of time coalesce to form laminæ, a condition not unlike that occurring in shell, as has been so well described by Dr. Carpenter, or rather like that which takes place in the formation of most of the laminated kinds of urinary calculi.

My object in bringing the subject before the Society at this time is to ask those of our members who are chemists, and would be willing to look into the matter, if they could determine the nature of the residuum or basis left after the destruction of the earthy ingredient by means of the acid. They will find, as I shall presently have the opportunity of showing you, that there is something peculiar in the dissolution of the crystals—they are all, more or less, granular, as if the organic matter were not confined to the investing membrane, but intimately mixed up or incorporated with every atom of the lime. I have this day examined some sections of the Soap wood of China, in which stellate masses of crystals are very abundant. If these be acted on by dilute hydrochloric acid, the earthy constituent will disappear, but a cast of the original mass will be preserved in what may be termed organic matter. This point, however, is the one which requires to be carefully examined by persons more skilled than myself in the science of organic chemistry.

As far as my observations have hitherto gone, it would appear to be a rule that we rarely, if ever, find inorganic material in the vegetable or animal kingdom, except in the crystalline state, without the existence of an organic basis.

Since the above was written, my friend Dr. Lionel Beale has been kind enough to examine the raphides in question, and the following is his report on the subject.

" A few of the white globular crystalline masses were treated with boiling distilled water, and the aqueous solution, after being filtered, was evaporated to a small bulk. Upon examining the residue by the microscope, numerous small colourless crystals, in the form of obtuse rhomboids, were observed. The residual solution was found to give precipitates insoluble in strong nitric acid, with solutions of nitrate of barytes and nitrate of silver, proving the presence of chlorine and sulphuric acid. Oxalate of ammonia gave a precipitate insoluble in acetic acid, but soluble in strong nitric acid, showing the presence of lime.

" Hence boiling distilled water extracted a small quantity of soluble matter, which contained lime, chlorine, and sulphuric acid, probably in the form of sulphate of lime and chloride of sodium.

" *Acetic Acid.*—The crystalline masses were not affected by boiling acetic acid.

" *Potash.*—No observable action was produced by boiling a few of the masses in solution of caustic potash.

" *Nitric Acid.*—Upon the addition of strong nitric acid, effervescence occurred with some few of the bodies as they dissolved, but upon the majority this re-agent exerted little action in the cold. When the mixture was boiled, complete solution immediately took place.

" The acid solution was evaporated to dryness; the dry residue was boiled in distilled water, and the filtered solution, after concentration, was allowed to remain in a still place for some time. Upon examining the residue with the microscope numerous well-formed octohedra of oxalate of lime were observed.

" Another portion of the original matter was incinerated:—the masses still retained their globular form, but became black, and the products of combustion burnt with a blue lambent flame. After exposure to a dull red heat for three or four hours, the crystals were perfectly decarbonized, and by the unaided eye could scarcely be distinguished from those which had not been incinerated. Upon microscopical examination, however, the crystalline fragments of which the crystalline masses were composed, were found to have acquired a dark granular uneven surface, and the sharpness of outline had been destroyed. The decarbonized residue was entirely dissolved in acetic acid with brisk effervescence; and upon the addition of a solution of oxalate of ammonia to the acid solution, an abundant white precipitate was immediately produced; this was soluble in strong nitric acid, but insoluble in excess of acetic acid—*oxalate of lime.* In all probability, therefore, the crystalline masses consisted of—

"1. A little organic matter;
"2. Sulphate of lime;
"3. A little of carbonate of lime;
"4. Traces of chloride of sodium;
"5. A vegetable salt of lime, containing a considerable proportion, or consisting entirely of *oxalate of lime.*"

On the occurrence of a Membranous Cell or Cyst upon the Olfactory Nerve of a Horse, containing a large Crystal of Oxalate of Lime. By JAMES B. SIMONDS, Esq. (Read April 28, 1852.)

THE recent publication of Mr. Quekett's lectures on the occurrence of earthy salts in both animal and vegetable cells gives an unusual interest to these depositions, and more especially when they are met with in those parts of the organism of animals where we should scarcely anticipate their presence. For this reason, and as an addendum to his valuable papers now being read before the Society, I am induced to bring before you an interesting and novel fact which has lately come to my knowledge relating to a deposit of the oxalate of lime within a cell or small membranous cyst.

In the latter part of March a pupil of the Royal Veterinary College found, in dissecting the brain of a horse which had been procured from the slaughterhouse, a small transparent cyst, possessing a very bright or glistening aspect, attached to the bulbous portion of the right olfactory nerve. The specimen, together with a small portion of the nerve, was carefully removed, and a day or two afterwards it was kindly presented to me, he at that time believing it to be an hydatid.

From having been kept in water I found that the nerve was somewhat decomposed, and very readily separated into a pulpy mass; a circumstance which prevented any minute examination of its structure being made. I observed, however, that its substance was partly absorbed, so as to form a cup-like concavity for the lodgment of the cyst; and I am led to infer from this circumstance that the sense of smell of the animal was greatly interfered with, and probably rendered very obtuse. But of this, as well as the existence or otherwise of pain from the pressure of the cyst, we are without means of ascertaining.

On placing the specimen under the microscope, and viewing it with a two-inch object-glass, I was surprised to find a large octohedral crystal of oxalate of lime, with beautifully defined facets freely floating in a limpid fluid which distended the walls of the cell. There appeared to be no obstacle to the passage of the crystal from side to side of the cavity or in any other direction when the specimen was placed in different positions, its weight quickly carrying it to the most depending part. The walls of the cell have every indication of being composed of layers of areolar tissue spread out in a membranous form; they are not, however, of uniform thickness throughout, although everywhere very translucent. Towards the circumference or periphery of the cell on one side there exists a bell-shaped spot (*a* Fig. 1, Pl. IV.), which is thinly covered with membrane, but surrounded with many fibres, far more dense than in any other part. Besides the crystal within the interior there is a small mass of granular-like matter, which can also be made to vary its position; this mass is marked *b*.

The occurrence of this deposition of the oxalate of lime in this situation is the more interesting from the circumstance that this salt of lime is very rarely met with in the urine of the horse, in which the carbonates, on the contrary, are very common. Various forms of the carbonate of lime are noticed in the urine of the herbivora, produced by causes disturbing its ordinary mode of crystallization; but none of these forms can be confounded with the octohedral arrangement of the oxalate.

The priority of the formation of the cell or the crystal is not easy to be determined, it being possible that the blood of the animal, from impregnation with the oxalate of lime, deposited this salt in the place it was found, and that subsequently a cell enclosed it to prevent any serious ill consequences to the surrounding organism; or it may be that the cell was first formed, and then the salt was effused into its interior, where it led to the exudation also of fluid. It is perhaps right to mention, in conclusion, that several capillary vessels are to be observed ramifying upon the walls of the cyst, and that it was firmly held in its place by fibres of areolar tissue. I may also add that the crystal has not been measured to ascertain its exact size, but that it can very readily be seen by unassisted vision.

On the Development of Tubularia indivisa. By J. B. MUMMERY, Esq. [Read May 26, 1852.]

HAVING found considerable difficulty in reconciling the accounts given by various naturalists of the development of *Tubularia indivisa*, I was gratified to have discovered a locality whence I could obtain by the dredge a regular supply of fresh specimens of that very interesting zoophyte; and during the past six months have made almost daily observations by the microscope upon its structure and development.

The painstaking investigations of the late Sir John Graham Dalyell appear to have supplied much of the information published on the subject.

It appeared however to me, on comparing the results of my own observations with the accounts and figures contained in the work of that indefatigable observer, that he had ever laboured under the disadvantage of employing a very imperfect microscope, and consequently misapprehended some of the phenomena to which he directed his patient attention.

The general form of *Tubularia indivisa* has repeatedly been well described, but there are some portions of its structure respecting which greater accuracy appears desirable. The reproductive gemmules have usually been described as originating at the base of the lower row of tentacules, and, owing to the profusely crowded situation of these oviform bodies in the full-grown head, it is quite impossible to detect their real place of attachment to the body. It is however a well-known fact, that the full-grown head within three or four days drops from the stalk, and that in the course of six or seven days a new head is produced from the medullary pulp. On examining the newly-formed head, under a magnifying power of fifty diameters, the oviform gemmules are even at this early stage perceptible, arranged upon the outer surface of the body, and extending vertically from the lower tentacules to the base of the oval tentacules in twelve equidistant lines; two of the lower tentacules originating in the space between each ovary, thus making the whole number twenty-four.

In the early stages of their growth the capsules are attached to the ovary by a very short and somewhat thick stalk; the stalk gradually becomes elongated, having the capsules affixed alternately on each side throughout its length by a broad attachment, and the substance of the capsule is now of a pale rose-colour.

As development advances the general rosy tint disappears, and the colouring matter appears concentrated in a well-defined organ of deep-red colour, which evidently supplies the connecting link between the stalk and the enclosed embryo, and has been denominated the placental column. The pedicle, attaching the capsules to the stalk, having now become much smaller in proportion, the stalk, with its capsules, presents the appearance of a bunch of grapes. Sir John Dalyell declares his inability to discover the ascending and descending currents conveying granular matter, which have been observed in the stem of *Tubularia* by several naturalists. In addition to these, however, I have distinctly noticed similar, though not equally energetic currents, in the stem supporting the reproductive gemmules.

The writer just named appears to have never detected more than one embryo in each cyst, but in some specimens I have found each cyst in the group to contain two, and occasionally even three embryos, distinctly perceptible through the sides of the cyst, which is sometimes quite transparent.

While some clusters are fast approaching maturity, others, attached to the same ovary, are still in the very earliest stages of growth.

As the contents of the capsules at length arrive at maturity, a bright red spot (which for some weeks past had become perceptible at the apex of the capsule) is observed slowly to expand in a quadrangular form, presenting the appearance shown in fig. 3, Pl. IV.

The basal extremity of the nascent animal is now seen slowly emerging,—the drawing (in the particular instance illustrated) exhibiting the progress of development at intervals of an hour, commencing at 8 30 P.M., and concluding at 1 30 A.M., when the process of extrication was complete. The extremity which will form the future point of attachment in the fixed state of the young animal is always presented towards the aperture of the capsule, which appears to be dilated solely by the efforts of the animal.

Slowly it emerges, withdrawing its tentacles in succession, until it has set itself free, when it crawls slowly upon the bottom of the vessel containing it, elevating itself on the extremities of its eight tentacles.

After a period of time, varying from one to four days, the animal (which, in its free condition, has never been remarkable for activity), having selected a suitable stone, or the surface of an old polypidon, reverses its position, and, with the mouth upwards, now attaches itself by the opposite extremity, and remains rooted fast for life.

In every instance that has come under my notice, the first animal that escapes is of an ellipsoidal form, not very greatly differing from the adult, excepting in the number of its tentacles. Within five minutes after the extrication of the animal already described, a second escapes through the dilated mouth of the capsule, but differing greatly from the former in configuration. It closely resembles, in miniature, a young specimen of one of the star-fishes (*Solaster papposa*), presenting a discoidal form, surrounded by twelve obtuse tentacles.

In the course of thirty-six hours this had greatly changed in form, and, within a few days after, the two varieties presented but slightly different aspects, especially after they had fixed themselves. The empty capsule, or ovisac, with its contained placental column, remains dilated, exactly as when the young animals quitted it.

After the lapse of about six weeks, the animals, which were previously colourless, gradually acquire a pale rose tint around the head, and eventually the ovaries are developed as it approaches the adult state.

Much difficulty is experienced in preserving this zoophyte in a healthy state for examination, but it may be worth observing that I at length succeeded tolerably well by connecting a syphon of gutta percha with a reservoir of salt water, and thus causing a small stream to fall from a height of several feet upon the surface of the water containing the specimens, and allowing the surplus water to overflow into a larger receptacle. The agitation thus produced had the effect of retarding the fall of the heads.

I trust I may be pardoned for referring to the highly interesting suggestion of Professor Forbes, in his admirable treatise on the naked-eyed Medusæ, viz.: That possibly all the Medusæ are, at one period of their life, fixed animals, as proved by Sars in the case of *Cyanea aurita;* and that, conversely, many of the zoophytes may be found to pass through a medium stage of existence, during which the germs are developed from which the zoophyte is reproduced,—as in the instances of *Laomedea* and *Cyanea.*

As the latter zoophyte presents so close an affinity to the subject of my remarks, I have most carefully repeated my observations, and feel convinced that the animal which escapes from the pedunculated capsule is distinctly traceable through all its stages, until, when fixed, it becomes the adult *Tubularia*, and that it undergoes no intermediate metamorphosis, or alternation in its mode of existence; I have thought it possible that the eight-armed creature might prove a Medusoid.

Some Observations on the Structure and Development of VOLVOX GLOBATOR, *and its relations to other unicellular Plants.* By GEO. BUSK, Esq., F.R.S. (Read May 26, 1852.)

THREE forms, or, as they are commonly regarded, species of *Volvox* are described and figured in Ehrenberg's great work, and have been noticed by other observers. These are *V. globator*, *V. aureus*, and *V. stellatus*. A fourth very similar organism has also been described under the name of *Sphærosira Volvox.*

As I regard the three first named of these at all events, merely as forms or phases of one and the same species, the following observations will apply in some respects to all of them. They have more particular reference, however, to the common form of *V. globator*, which happens to be that most accessible to me.

This beautiful and well known object, which was first noticed by Leeuwenhoek, received little satisfactory elucidation until it fell under the observation of Ehrenberg, whose account of its structure and notions respecting its nature have been adopted by most subsequent observers, and have been received with little opposition until very lately—in fact until the beginning of last year. At that time Professor Williamson read a paper on the subject before the Manchester Literary and Philosophical Society, which is published in the 9th volume of their Memoirs.

Professor Williamson's observations have led him to conclusions in many points opposed to those arrived at by Ehrenberg, and especially are they confirmatory of Siebold's original view of the vegetable nature of *Volvox.* With respect to some points of structure, however, concerning which Professor Williamson differs from the Prussian observer, I am inclined, from my own observations, to side with the latter, whose errors in the case of *Volvox* are not those of direct observation; but in this instance, as in very many others, it is obvious that Ehrenberg has allowed his imagination, working upon preconceived notions, to play the part of reason in the interpretation of correctly-observed phenomena; he has thence, in the explanation of what he has *seen* correctly, fallen occasionally into great and important errors. Whilst it cannot be denied that the recent progress of knowledge with respect to the structure and nature of the lowest classes of organised beings, places an observer of the present day in a position so much more advantageous, that it is scarcely fair to institute a comparison between him and the great and laborious Prussian microscopist, at the time his principal works were written, still it is much to be regretted that these modern lights, clear as they are, have not apparently been allowed to penetrate his mind, and that one to whom science is so much and so deeply indebted should retain views long since deservedly exploded by nearly all competent observers.

The more common and best known form of *Volvox globator*, to the naked eye, or under a low power, appears as a transparent sphere, the surface of which is studded with numerous, regularly placed green granules or particles, and which contains in the interior several green globules, of various sizes in different individuals, though nearly always of uniform size in one and the same parent globe.

These internal globes, which are the young or embryo *Volvox*, at first adhere to the wall of the parent cell, although the precise mode of connexion is not very apparent. When thus affixed, they are in a different concentric plane to the smaller green granules. At a later period, and after they have attained a certain degree of development, these internal globes become detached, and frequently exhibit a rotatory motion, similar to that of the parent globe.

In the form of *Volvox*, termed *V. aureus* by Ehrenberg, the outer sphere, or cell, exhibits precisely the same structure as the above, the only apparent difference between them consisting in the deeper green colour of the internal globules. These, however, soon exhibit a more important distinctive character in the formation of a distinct cell-wall of considerable thickness around the dark green globular mass. This wall becomes more and more distinct; and, after a time, the contents, from dark green, change into a deep orange-yellow; and simultaneously with this change of colour the wall of the globule acquires increased thickness, and appears double.

The third form, or *Volvox stellatus*, differs in no respect from the two former, except in the form of the internal globules, which exhibit a stellate aspect, caused by the projection on their surface of numerous conical eminences, formed of the hyaline substance, of which the outer wall of the globule is constituted. The deep green colour of the contents of these stellate embryos, and their subsequent changes into an orange colour, at once point out their close analogy with those of *V. aureus*. I have no doubt of their being merely modifications of the latter; and, in fact, the two forms are very frequently to be met with intermixed, and on several occasions I have observed smooth and stellate globules in the interior of one and the same parent globe.

The organism described and figured by Ehrenberg, under the name of *Sphærosira volvox*, also presents the appearance of a transparent globe set with green spots, but it differs from the foregoing in two important respects.

1. In the absence of any internal globules or embryos.

2. In the irregular size of the green granules lining the wall, which, instead of being of a uniform size, are of various dimensions (fig. 13, Pl. V.). The different sized granules are irregularly disposed, although, in relation to the sphere itself, they, or rather the centres of them, are as regularly distributed as in the three just-described forms. What is rather remarkable with respect to this form is the circumstance, that the larger granules are not disposed over the whole periphery of the sphere, rarely occupying more than two-thirds of it, towards one side. In the more minute description of the elements of the above-mentioned organisms, the investigation of which requires the higher powers of the microscope, it will be convenient to commence with the common *Volvox globator;* and as the tracing of the development of the internal embryonic globules affords the readiest road to a comprehension of the true structure of the mature globe, I shall proceed in that course.

The internal embryonic globules are visible in the young *Volvox* while still within the parent; but as they are at first concealed by the density of the wall of the young *Volvox*, the very earliest stage of formation of the embryo cannot be readily noticed. In the earliest state in which these bodies can be observed, they appear as a globular, or rather discoid, nucleated cell (fig. 3), which, besides its apparent central nucleus, contains a number of minute spherules placed towards the periphery. At this time no distinct wall can be detected, the whole embryo (to use a convenient though incorrect term) apparently consisting of a homogeneous substance, with a lighter nuclear-looking space in the centre, and the above-mentioned spherules towards the periphery. This nucleated cell, as it may be termed, although without a cell-wall, increases in size, and the solid or coloured contents appear to retreat from the centre, which becomes clearer and clearer towards the periphery, which gradually becomes more and more opaque. As the cell grows, the nucleus (?) seems to disappear, or to be converted into the clear central space; or, it may be, broken up and confounded in the more opaque contents. The number of spherules increases as the cell grows, and it is very soon apparent that the now very thick parietal deposit of cell contents is breaking up into small portions or lobular masses, the centre becoming clear, and apparently filled only with a clear aqueous fluid. When the cell has thus acquired a considerable size, the contents begin to undergo segmentation, as pointed out in the case of *Volvox*—I believe first by Professor Williamson. This process commences and proceeds precisely as in the ova of animals—the contents dividing first into two, and then each of the halves into two, and so on, till the division becomes too minute to allow of the counting of the segments. It is to be remarked, moreover—and I think this has not been noticed before—that the bright spherical bodies multiply quite as rapidly, if not in a more rapid ratio, up to a certain point, than the segmentation goes on, so that each segment of the still-dividing mass always exhibits two, three, four, or even more of these particles (figs. 1, 2). Ultimately the segmentation ends in the formation of innumerable green bodies, which are closely packed round the periphery of the cell. These bodies, though perfectly defined, are not at first separated by any clear space, and each contains at least one of the bright spherules alluded to (fig. 3). By their mutual pressure, these soft corpuscles of course assume an hexagonal figure, and they are now about 1-4000th of an inch in diameter, or rather more. As soon as, or even before, the segmentation commences, a distinct though delicate membrane, surrounding the embryonic mass, is quite evident, as described by Mr. Williamson; and beyond this is usually to be observed a very delicate zone of apparently gelatinous matter, which is sometimes so delicate as to escape observation, but may, I believe, always be detected by the use of a solution of iodine.

When the segmentation is completed, in the way above described, the embryo *Volvox* exhibits the appearance of a spherical body composed of a transparent membrane lined with distinct, uniform-sized, contiguous hexagonal masses. It continues to grow, and very soon clear lines become apparent between the green masses, which are thus very distinctly defined, retaining the same hexagonal form—each with an apparent nucleus, which is probably derived from the bright spherule contained in it, but as yet without brown spot, clear space (vacuole), or vibratile cilia. As the embryo continues to grow, the spaces between the green masses continue to increase; the green bodies gradually lose the hexagonal form, and assume the appearance of the ciliated zoospore next to be described. They are now about 1-3000th of an inch, or thereabouts, in diameter, and the embryo, detached from its parent, becomes a free *Volvox* in its interior. We have thus arrived at the complete *Volvox*, and from the mode of its formation it is apparent that it consists of a transparent wall lined with the green bodies, and hollow in the interior; and also that it is surrounded, at all events while within the parent, with a delicate transparent areola, apparently of gelatinous matter We have now to examine more minutely the structure and nature of the green granules, and the further changes they undergo.

Upon examination of the wall of a full-grown *V. globator* with a sufficient magnifying power, it will be seen, upon viewing the edges, as it were, of the image in the field, with the object so arranged as to bring the equatorial plane exactly into focus (fig. 5), that the green granules are, in fact, vesicular or semivesicular bodies of a flask-like or conical form, about 1-3000th of an inch in transverse diameter, and placed at uniform distances apart. Each of them is prolonged outwardly into a sort of peak or proboscis of a transparent and colourless or hyaline material, and from which proceed two very long vibratile cilia, which in close contact at first, pass through the parent cell-wall, upon the outer side of which they separate widely and perform very active movements. The outer cell-wall presents a minute infundibuliform depression at the point of exit of the cilia. It will also be observed, that each ciliated cell or zoospore, as it may analogically be termed, contains a green granular mass or masses, composed, for the most part probably, of chlorophyll granules and a more transparent body, which I suppose may be regarded as a nucleus, and derived, as it would appear, from one of the bright spherules which have been noticed before. At an early period after the maturity or completion of the zoospores they exhibit a minute, circular, clear space, or sometimes, but I think rarely, more than one, which is worthy of very attentive consideration. This space is of pretty uniform size in all cases, and about 1-9000th of an inch in diameter. It may be situated in any part of the zoospore, or not unfrequently in the base, or even in the midst of one or other of the bands of protoplasm connecting it with its neighbours. Its most important character consists in its contractility—a property already known to be possessed by similar spaces or vacuoles in vegetable spores. But what appears to me a very curious, and as yet unnoticed peculiarity of this contraction, consists in the fact that it is very regularly rhythmical. In several cases in which I have watched the phenomenon in question, uninterruptedly, for some time, the contractions or pulsations occurred very regularly at intervals of about 38″ to 41″. In one case, however, if I was not misled in the observation, the interval was about twice this, viz., 1′ 25″. The contraction, which appears to amount to complete obliteration of the cavity of the "vacuole," takes place rapidly or suddenly, as it were, whilst the dilatation is slow and gradual. The interval above noted was measured between one sudden contraction and the next, and about half of it perhaps was taken up by the slow dilatation of the space. This contractile vacuole always reappears in precisely the same spot. It would seem to exist, or at all events to present a contractile property only for a limited period, and to disappear soon after the formation of the brown spot, when, as I conceive, the zoospore has reached its maturity. The most favourable cases in which this contractile space is to be sought for, are those in which the *Volvox* is in the most vigorous state, and especially in that variety in which, owing perhaps to the copious supply of nutritive matter, the amount of protoplasm is very abundant, and the zoospores consequently very numerous and connected to each other, not by slender filaments but by wide processes, as in figs. 26, 27, which latter shows a contractile space situated in the base of one of the connecting bands of protoplasm. With the exception of the small space occupied by this contractile spot, the zoospore at first appears to be quite solid, and no distinct wall can be perceived around the green matter, but it rapidly changes. Owing either to the expansion of the vacuole, above described, after it has lost its contractile property, or to the formation of others of a different nature, and also perhaps in some degree to the absorption or consumption of some of the colouring contents, the zoospore gradually becomes more and more transparent (fig. 7); till at last, the greater part of it is clear and colourless, and what remains of the green matter contracts into a small irregular mass, adherent to the bottom or sides of what is now a cell—primordial cell of Cohn. (Figs. 5, 6.)

Each cell, when fully formed, usually presents a brown spot, which is adherent to one side of the cell towards the narrow end (figs. 5, 6); and what is remarkable, it will be noticed in a perfect specimen, that the brown spots are placed in a corresponding situation in all the cells, that is to say, all the cells appear to look the same way. This is the so-termed eye-spot of Ehrenberg. When examined with a high power (800—900 diam.) it presents the form of a cup or disc, concave on the side which looks outward, and convex on the other. Though placed quite on the side of the cell, and projecting a little upon it, the brown spot is nevertheless always covered by a thin membranous expansion of protoplasm, or, in other words, it is always lodged within the substance of the zoospore. Though most usually present, the brown spot does not appear, in all cases, to be at any period a necessary constituent of the zoospore. It is one of the most persistent however, remaining visible as long as any portion of the zoospore is discernible. Besides the above-described elements, the zoospore, when viewed from above, exhibits two highly refractive spots placed side by side, which seem to represent the insertions or origins of the two vibratile cilia.

The periphery of the cell presents a clear line, and appears to be formed of a delicate membrane—although, in the earlier stages of the existence of the zoospore, that is, before the formation of the eye-spot, or disappearance of the contractile vacuole, the whole evidently consists of a homogeneous substance, in which the above described parts are imbedded. From the periphery of the zoospore proceed six thread-like processes, connecting it with as many of its neighbours. These threads appear to be simply continuations of the *quasi* cell-wall, and to be of the same nature chemically as it, as are also the vibratile cilia. The connecting threads are sometimes double, or even triple, between some one or more of the surrounding cells, and they are invariably continuous between the two cells.

This description applies more particularly to the zoospores *in situ*. When the *Volvox* is ruptured, many appear to become immediately detached, and to be washed out, as it were, with the aqueous contents of the parent cell. Under these circumstances they lose some of their previous regularity of form, but not much; they become more globular and the beak less prominent, but in other respects they appear much the same as before. The two vibratile cilia remain in connexion with them, and continue their active movements. This is opposed to Mr. Williamson's statement, that " when thus liberated they exhibit no traces of the two cilia, or proboscides" of Ehrenberg, and agrees with that of the latter. Among the thus liberated ciliated zoospores will usually be found numerous detached cilia, which, as is observed by Mr. Williamson, are generally more or less coiled at one end into a ring. And besides these I have not unfrequently noticed some extremely delicate annular bodies, about 1-9000th of an inch in diameter, perfectly clear and colourless, which seem as if they had escaped from the interior of the ruptured zoospore: but of this and their true nature I am unable to speak positively.

Having thus described what I conceive to be the anatomy of the common form of *Volvox globator*, I will thus sum up the result of what my observations have led me to conclude as to its structure.

1. That it originates in an apparently nucleated, discoid cell, which is generated in the interior of the parent, and liberated in a perfect, though not fully matured form; within which are contained similar germs.

2. That the contents of this apparently nucleated discoid cell, consisting of a grumous material and refractive amylaceous (?) spherules, after a time undergo segmentation, at the same time exhibiting a distinct wall, beyond which is a delicate areola, apparently of a gelatinous consistence.

3. That this segmentation, attended with a corresponding augmentation in the number of the refractive spherules, terminates ultimately in the formation of numerous contiguous particles or segments.

4. That these ultimate segments are gradually separated from each other, remaining connected only by elongated processes or filaments, and constituting the ciliated zoospores of the mature *Volvox.*

5. That these zoospores at first are simple masses of protoplasm, containing a transparent nuclear body, and that afterwards they present for a time clear, circular spaces, which contract rhythmically at regular intervals; and are subsequently furnished with a brown eye-spot; and at a very early period with two long retractile cilia, which, arising from an elongated hyaline beak, penetrate the parent cell-wall, and exert active movements external to it.

6. That in a concentric plane internal to these ciliated zoospores are placed the germs of future individuals destined to follow the same course.

Having thus traced one form of *Volvox* through its course of development, I will proceed much more briefly to the others.

In *V. aureus*, as I have said, the constitution of the wall of the parent cell is exactly as above described. At its earliest appearance also the internal embryonic body cannot be distinguished from that of the ordinary form, except in its deeper green colour. It afterwards, however, acquires a thick wall, changes its colour to yellow without material alteration in size, and acquires a second equally firm and distinct envelope, or rather, as I believe, the original contents contract somewhat, and then form a second coat around themselves. Eventually a considerable space exists between these two coats (figs. 10, 12), which space is occupied by a clear and apparently aqueous fluid, but upon the addition of a solution of iodine a granular cloudiness is produced in this fluid. The contents of the inner cell consist chiefly of amylaceous grains mixed with a greenish material in the one case, and with a bright yellow apparently oily fluid in the other. The amylaceous particles are of an irregular botryoidal form, and far from uniform in size. As regards the future destination of this form of germ, I am as yet in total ignorance; there can, however, I think, be little doubt but that it represents the "still" form of spore of other Algæ—that it may, in fact, be termed the "winter spore" of *Volvox*, destined, owing to its more persistent vitality, to continue the species, when its course of development in the usual way is interrupted by surrounding circumstances.

Of that form of *Volvox* termed *V. stellatus*, I would only here observe that it seems to me merely a modification of the one last described, and that it appears to follow the same course of change and doubtless of future development.

With respect to *Sphærosira volvox*, my observations have been very limited, and I by no means desire to express myself with certainty as to its relationship to the forms above described. I merely surmise that it may be found to represent a peculiar mode of development of one and the same species.

In external aspect, except in the want of uniformity in the size of the ciliated zoospores, it appears to agree in all respects with *V. globator*. It however contains no internal embryonic bodies, and it is therefore only to the ciliated cells that any reference need here be made. The smaller ones appear to me to resemble in all respects those of *Volvox globator*, and each to possess two cilia, which is important if true, because the only distinction between *Volvox* and *Sphærosira* in Ehrenberg's classification depends upon the circumstance, that in *Sphærosira* there is only a single cilium to each zoospore, whilst there are two in *Volvox*.

My supposition that *Sphærosira volvox* and *V. globator* are allied, is founded, it must be owned, not upon any direct observation, but chiefly upon the fact, that in the water in which the specimens of *Volvox* I had under examination were contained, there was at first none of the *Sphærosira* any more than of *V. aureus* observable, and that after some days both were very numerous.

The difference I am about to describe in the after development of the ciliated zoospores, is not by any means a sufficient ground upon which they should be deemed distinct species, because much greater differences are known to exist in other of the lower Algæ during their various forms of development without its being thence allowable to suppose that they are of different species.

In *Volvox sphærosira* then, as at all events it may be termed, the larger green granules are in fact the ciliated zoospores in a stage of further progressive development. In the same specimen they will be seen in all stages of division or segmentation (fig. 13)—first into two, then into four, and so on till, as in the case of the embryo *Volvox*, the ultimate result of the segmentation constitutes numerous minute ciliated cells or bodies (fig. 14)—not, however, as in that case, lining the inner surface of the wall of a spherical case, but forming by their aggregation, a discoid body, in which the separate fusiform cells are connected together at one end, and at the other are free, and furnished each with a single cilium. In this stage these compound masses become free and swim about in the water, constituting, in fact, a species of the genus *Uvella*, or of *Syncrypta* of Ehrenberg.

With respect to the chemical constitution of the above described parts, the following are the results at which I have arrived:—1. By the use of iodine and sulphuric acid, tried repeatedly and in various ways, I have never succeeded satisfactorily in eliciting any tinge of blue in the wall of the mature *Volvox*. I therefore conclude that it contains no cellulose. It is invariably coloured, by the above re-agents, of a deep brown colour, and when thus coloured, this outer wall presents no trace whatever of structure; it appears uniformly transparent and homogeneous. The ciliated zoospores, also, with the connecting filaments and cilia, are turned brown, but of a very deep brown, by the same re-agents, excepting usually one or more particles in the interior of each, which are apparently turned blue. I am not satisfied as to the chemical re-action of the brown spot; it appears to assume a blue colour, but from the intensity of its colour and consequent opacity I am not sure that this is the case.

The embryo cell, when young, is turned a deep brown, but when older and fully formed, but before it has arrived at maturity, it will be found that it is only the green masses, or future ciliated zoospores, that are thus changed, the cell-wall acquiring scarcely any tinge of brown. But when a young cell thus tested with iodine and sulphuric acid is ruptured, I have occasionally noticed that the fluid contents contain an abundance of minute bluish flocculi—I use the word flocculi because the particles are light and flocculent, and not at all like any of the more ordinary and more solid forms of amylaceous matter. The quantity of this flocculent matter appears to be greater towards the periphery of the cell, and, in fact, it would seem that the green bodies are at this time imbedded as it were in an amylaceous matrix, which they not improbably assimilate, because in the mature cell nothing of the sort is apparent.

In the embryonic bodies, however, or winter spores of *V. aureus* and *stellatus*, the presence of cellulose is rendered abundantly evident in the two coats forming the tunic of the spore by the blue colour produced in them by iodine and sulphuric acid (fig. 11); nearly as distinctly, in fact, as it is in the tunic of *Micrasterias* and other *Desmidieæ*. The apparently clear fluid between the two tunics is rendered brownish and turbid at the same time (figs. 11, 12), and the solid contents of the interior are shown to consist, for the most part, of amylaceous grains of the peculiar botryoidal form above noticed. (Fig. 9.) The yellow oil-like fluid in the ripe spore acquires a green tint under the action of the same re-agents. (Fig. 9.)

Appendix.—(*October*, 1852.)

The above are the observations read at the Microscopical Society. I am now satisfied that they afford an account of but one of the multiform varieties under which *Volvox* occurs at different times and places. I must own also, that at the time my observations there detailed were made, I was unable to reconcile much of what I saw with some of the statements and figures in my friend Professor Williamson's ingenious paper on the same subject. Subsequent investigation, however, and some correspondence with him, have satisfied me that I was hasty in drawing conclusions from one form only of a very protean object. I freely confess, that in much, in respect to which I had conceived Professor Williamson had fallen into some error of observation, he has been quite right, though at the same time I must say that his explanations of the appearances described and figured by him, do not exactly accord with my notions respecting them. I still maintain that the structure of the wall of *Volvox*—upon which alone I think we are disagreed—is essentially such as I have described it, viz., that it is formed by a continuous, external tunic, lined by the ciliated zoospores. Professor Williamson, on the other hand, as I understand him, conceives the globe to be "a hollow vesicle, the walls of which consist of numerous angular cells filled with green endochrome, &c., the intercellular spaces being more or less transparent." The ciliated zoospore, therefore, according to him, is not a mass of vegetable protoplasm, without distinct wall, and precisely analogous to a *Euglena*, or other naked zoospores, but represents the endochrome of a cell having two walls, an external and an internal, which latter is "a ductile cell-membrane, lining the interior of each cell and surrounding the cell-contents," and which "inner membrane becomes separated from the outer cell-wall excepting at a few points, where it is retained in contact." And he thus explains the mode of formation of the connecting filaments. In this case, therefore, these filaments would never pass directly from one green mass to another, but would of course be interrupted in their course by the walls of two contiguous cells. That this, however, is not the case in the form of *Volvox*, which formed the subject of my paper, is sufficiently obvious. But it is nevertheless true, as I find from examination of Professor Williamson's specimens, that his representation is, in certain cases, equally correct, as I shall afterwards explain. Another circumstance also noticed by Mr. Williamson, and which, till he pointed it out particularly to me, had, though not altogether unnoticed, been disregarded, is the existence of delicate lines between the green granules, and dividing the wall of the *Volvox* into very regular hexagonal spaces, in the centre of each of which is placed one of the green granules. The former of these conditions— which, though I have never met with it myself distinctly in specimens from any other locality, seems to be sufficiently abundant in the neighbourhood of Manchester—is represented in figs. 15, 16, 17, 18, 19, 20. In these it will be seen that the central green body is surrounded, at variable distances, by a tolerably thick, distinct membrane or wall, and that numerous irregular filaments, where they exist at all, extend from the central mass to this wall, and there terminate, and do not pass from one green mass to another, as in the usual form. Now, I explain the way in which the zoospore is thus modified, in this way: I regard the external membrane merely as the boundary-wall of the original zoospore, and, like the entire body, as composed of vegetable protoplasm; and I believe that this peculiar appearance is produced by a great and unusual expansion of the interior of the zoospore (by endosmosis of fluid probably), by which the outer or peripheral layer is separated from the remainder and principal part of the mass, containing the chlorophyll and nucleus, or supposed nucleus, &c. Zoospores, in fact, in this condition might be said to be dropsical. That this separation of the wall from the contents arises in this way, and not, as Mr. Williamson says, from the shrinking of contents, is, I think, sufficiently obvious from several considerations, and is rendered very clear, if we trace the progressive stages of the hydropical enlargement in one and the same *Volvox*, as I have done in the figures above cited.

In this series it is easy to observe the earliest formation of the clear space up to the most extreme dilatation of which the cell is capable, owing to its contiguity with others. Of course when a number of cells are thus enlarged and mutually compressed, they assume an hexagonal form; but this hexagonal arrangement must not, as it appears to me, be confounded with another, to which I have before alluded, and which I conceive to be due to a different circumstance altogether. In fig. 15 of this series, some cells will be observed little if at all altered, from what I assume to be the normal form, and it will be seen that these little altered cells are mutually connected by the usual continuous filaments. In fig. 16 the zoospores are more expanded, and being in contact in many points, the connecting threads are absent; fig. 17 shows a further degree of expansion, but more irregular, and with irregular connecting filaments. In fig. 18 the enlargement is nearly as great as it can be, and numerous threads or processes of protoplasma extend from the central mass to the wall, just as they do in almost any vegetable cell from the nucleus to the primordial utricle, which utricle, in fact, is represented by the cell-wall in the case we are discussing. In fig. 19, the dilatation is complete, and, owing to the greater age of the specimen from which this figure was taken, the protoplasma is much wasted, and all the filamentary processes completely gone. A faint granular appearance occupies the cavity of the primordial cell. It is a curious fact, as showing perhaps that all the vital action in the cell resides in or around the nuclear mass, that not unfrequently the central mass after considerable expansion of the cell, and the formation in that way of one wall, will begin to throw off a second. This condition is represented in a more highly magnified drawing in fig. 20.

Although I have not myself seen any natural specimens in which this condition of the zoospores was present, except those for which I have been indebted to Mr. Williamson, still I have repeatedly observed a partial appearance of the same kind to take place, when a specimen of *Volvox* of the normal sort is kept for some hours under observation in the microscope. Figs. 21, 22, 23 show the series of changes that took place in a certain number of zoospores watched at intervals, and left undisturbed for about twenty-four hours. (Fig. 21, 10 A.M., Oct. 4. Fig. 22, 1 P.M., Oct. 4. Fig. 22, 8 A.M., Oct. 5.)

Now with respect to the other form of hexagonal areolation, for my knowledge of which, as I have stated, I am chiefly indebted to Professor Williamson, and which is represented in figs. 24, 25, I have already observed, that I regard it as quite distinct from that produced by the mutual pressure of contiguous dilated zoospores. Professor Williamson appears, from what he has told me by letter, to consider that this appearance is invariably present, or at all events that it can be elicited in all cases by appropriate means. I must confess however, that I have not been successful in seeing it, or in producing it in very many instances, and that I believe it is occasionally impossible by any means to demonstrate its existence. At some periods not a single specimen from a given locality will exhibit it, whilst at another, every individual will show it at the first glance. Thus in the month of August last, when, in a certain pond on Blackheath there was the most incredible abundance of *Volvox*, so great in fact as to render the water at the lee side of the pond in certain spots of a deep green colour, and to cause it to afford, when collected, a very strong herbaceous or confervoid smell, the majority of the plants exhibited the stellate form of spores, or rapidly acquired spores of that character, and very many were in, or soon assumed, the form of *V. aureus.* They seemed in fact to be entering upon their hybernating state. Many among them, however, though all small and starved-looking, were of the common kind; in all these Mr. Williamson's hexagonal areolation was very distinct. In the month of October, however, upon returning to the same pond, I was able to find very few *Volvoces* at all, and all of the usual kind; in none of these could I detect the least appearance of the same arrangement. I therefore conclude that the greater or less distinctness, or complete absence of this character, is to be referred to external conditions with which we are not fully acquainted. The appearance itself I explain in this way. It appears to me that each zoospore is imbedded in a distinct gelatinous or semi-fluid envelope of considerable thickness, and that the hexagonal areas are formed by the sides of these distinct masses of gelatinous matter coming into contact. I am inclined to think that there is no distinct membrane containing this gelatinous matter: if there be, it must be infinitely thin, because the line of contact is extremely delicate and single. I conceive, in fact, that each ciliated zoospore is surrounded with a gelatinous or semi-fluid areola, of the same nature precisely as that which surrounds the embryo *Volvox* while within the parent, and in which also it is not I think possible to detect a distinct limitary membrane. This envelope of the ciliated zoospores contains a nitrogenous element, which sometimes, on the addition of iodine, gives rise to the appearance of minute beads around the outer periphery of each gelatinous mass, or in the lines of the hexagonal areas as seen in fig. 25. It is to be observed also, that connecting filaments of protoplasma may occasionally be seen to pass from one zoospore to another across the line of junction of the two gelatinous envelopes (fig. 24). These zoospores therefore of *Volvox* would appear to represent the "encysted zoospore" of Cohn (*Protococcus pluvialis*, &c.), and his fig. 43, plate 67, may perhaps be taken as a fair representation of what I conceive to be the condition in these connected zoospores in *Volvox*. This explanation of the hexagonal areolation, however, does not clash at all with that which I have given as to the structure of the wall of *Volvox.* For in this case, as in all others, the collected mass of zoospores, and their envelopes, is enclosed by a continuous external membrane, not in any way derived from them but from the parent cell in which they were originally formed.

There are several other interesting points relating to *Volvox* which have come under my observation in a prolonged attention to the subject, including another form of development of the internal spore, in which it divides, not in the usual way, into what may perhaps not inappropriately be considered as macrogonidia, to use Braun's expression, but into a much smaller and differently arranged sort, which may be considered as his microgonidia; but to enter fully upon this and other points would demand more space than is here at command.

[Whilst this paper is passing through the press, I have found that a faint, but quite distinct, purplish blue tinge may be produced in the wall of *Volvox globator* by means of Schultz's solution. The specimens of *Volvox* in which I have noticed this have been preserved in glycerine for two months.—G. B.]

Further Elucidations of the Structure of VOLVOX GLOBATOR.

By Professor W. C. WILLIAMSON. (Read June 21, 1852.)

IN May, 1851, I had the honour of laying before the Philosophical Society of Manchester a memoir on the *Volvox globator*,* containing the results of a series of observations, which brought to light in that elegant object, a cellular structure, hitherto unobserved. Since the existence of these cells affects the character and affinities of the organism, it is desirable that the fact should be established beyond the possibility of dispute. My friend Mr. Busk, in a recent communication made to the Microscopical Society of London, either doubts their existence, or rejects my idea of their cellular nature. This denial, coming from such a quarter, renders it incumbent upon me to make the matter more plain than was done in my previous memoir: I am enabled to do this, partly by new observations on the living *Volvox*, and partly by some changes which the specimens prepared last year have undergone, making their structure more obvious than it previously was.

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* Published in the Ninth Volume of its Transactions.

No one who has seen these specimens can for a moment doubt that there exists immediately beneath the superficial pellicle, or common investing membrane of each *Volvox*, a layer of closely-packed translucent vesicles, within each of which is located one of the numerous green spots ornamenting its periphery. In the memoir referred to, I endeavoured to show that these vesicles are true cells, whilst the green spots are the inner cell-membranes and their contents, representing the internal utricles of Harting and Mulder, the primordial utricles of Mirbel. The appearance of these cells in their different stages of growth was described, and the mode of their development and multiplication examined.

Mr. Busk, who has recently directed his attention to this subject, has arrived at a different conclusion from my own, respecting the structures in question. Not having, then, seen the hyaline vesicles, which I regard as true cells, in any of his own specimens, he concluded that the *Volvox* consists of a number of protoplasms, which have resulted from the successive segmentations or subdivisions of one primary protoplasm, in the way described in my memoir. On being afforded an opportunity of examining some of my preparations of *Volvox* made last year, and in which the vesicles are remarkably distinct, though the appearance they presented was wholly new to him, he was still disposed to maintain his previous opinion. Instead of admitting them to be true cells, he concluded that they were merely the outer layers of the protoplasmic segments, which, after separating from the protoplasmic mass, had become dropsically distended, and assumed the appearance of a true cell.

Since I believe this general conclusion to be incorrect, I am anxious to render more clear than I have hitherto done, what appears to be the true interpretation of the structures in question. In accomplishing this, it will not be necessary to recapitulate all the details of my preceding memoir, since the accuracy of the greater number of them, as well as my conclusion respecting the vegetable nature of *Volvox*, are confirmed both by Mr. Busk and by other observers: some points, however, require to be examined in detail.

There is one point respecting which I was clearly in error; my present correction of the mistake is due to the suggestions which I have received from Mr. Busk. I found that each young germ was developed from *one* of the peripheral stratum of cells, by the ordinary process of cell-division or segmentation. Having ascertained that each protoplasm in its matured state was invested by a true *external* cell, in addition to a very thin inner one which held the granular mass together, I concluded that, in the earlier stages of the process of segmentation and development of the germ, each protoplasmic segment would be invested by a similar external cell-membrane, as is the case with *Hæmatococcus*, *Palmella*, &c. I could not ascertain what became of these outer cells, as successive subdivisions of their contained protoplasms multiplied their number, but hazarded the surmise, that the earlier cells might either have been re-absorbed, or that they still existed in the form of thin membranes, consolidated with and investing the newer cells which I supposed had been developed within their interior. It is now obvious that none of the protoplasmic segments have secreted their *external* cell-membrane, until the entire number destined to compose the matured organism has been completed. This interpretation accounts for many anomalous circumstances. It explains the very close contact in which we find the green protoplasms of the immature germ. No transparent spaces intervene; these only appear when the young germ is matured and furnished with cilia. It also explains my want of success in searching for the layers of cellulose, the residue of the supposed earlier-formed cells, which must have existed had the organism been developed in exactly the same way as a *Palmella* or an *Hæmatococcus*. In these latter objects, each segmentation of the protoplasm is followed by the secretion of a true cell, which invests each segment.

The point now to be demonstrated is the existence of *two* membranes surrounding each mass of protoplasm. First an inner one, very thin, and in the living state, closely embracing the granular protoplasm, and corresponding with the inner cell-membrane of the ordinary Confervæ; second, an *outer* cell-membrane secreted from the exterior of the first. To facilitate describing, we may term the former of these the protoplasmic membrane, and the latter the cell-membrane.

The protoplasmic membrane is easily shown to exist. Fig. 6, Pl. VI. represents a very young gemma, or budding germ, which consisted of but few segments, as it appeared when subjected to pressure under water. Some of the protoplasmic segments glided through an aperture made in the common vesicle, without becoming ruptured. They accommodated themselves to the size and form of the aperture, and, on escaping, regained their spherical form. On increasing the pressure, each segment burst, all the granular and mucilaginous contents flowing out and mingling with the water ($6\,b^1$). As they did so the protoplasmic membranes ($6\,c$) were distinctly seen as thin hyaline spheres. In the subsequent development of Volvox this membrane always continues in existence. Its appearance in the matured organism will be described immediately. When the gemma has attained its full size, by the process of segmentation described in my former memoir, further changes occur. Translucent spaces separate the green protoplasms, now become hexagonal by mutual pressure. These translucent outlines mark the development of the *external* cells investing the protoplasmic membranes. At first the two are in close opposition; they subsequently separate, as the cell increases in size, excepting at certain points where they remain in contact. Before tracing out the further stages of this process I must observe that the Volvox exhibits two apparently distinct states, which are, nevertheless, mere varieties of one species. In the one, each protoplasm assumes the appearance of fig. 1 *b*, being angular, and giving off thick, irregular and often dichotomous threads (1 *c*), the extremities of which are attached to the cell-wall (1 *a*). In this case, the radiating threads consist not only of the protoplasmic membrane, but also of its granular, mucilaginous contents. The other condition referred to is represented in fig. 10. Each protoplasm (10 *d*) is perfectly spherical, and connected with its neighbours by delicate capillary threads, these being so fine as to be sometimes almost invisible. In this state the cells to be described are often invisible; nevertheless, they exist.

The changes undergone by the stellate variety were described in my previous memoir. The cell expands, and as the protoplasm is only attached to it at certain points, the latter is drawn out until it finally assumes the stellate contour delineated in fig. 1. Each of the radiating threads is attached to the cell-membrane by its peripheral extremity, at a point exactly opposite the corresponding threads of contiguous protoplasms. On rupturing a Volvox under water these threads become detached from the cell-wall, and passing through the stages represented in figs. 2 and 3, assumed that of fig. 4, which is precisely that of fig. 10, minus the connecting threads, a state which occasionally occurs in the living Volvox.

In numerous examples of both these varieties of Volvox I found each protoplasm surrounded by an angular, usually hexagonal, areola, as represented in fig. 5 of my original memoir. They appeared as dark outlines when the object was illuminated by transmitted light. On exposing these specimens for a while to the action of some re-agents, as glycerine, I soon found that each dark line was really double, and marked the boundaries of two cells. This was shown by the gradual separation of these cells at the angles of the areolæ, as represented in fig. 11, which is a faithful transcript of part of one of these specimens when mounted in glycerine. In this example no cells were at first visible; but as I watched them, they came gradually into view in some parts of the organism, but not in others. Fig. 11 represents a portion of it, in the upper part of which the cells are visible, whilst in its lower part they cannot be traced; here the tissues were transparent and apparently quite structureless, as was the entire sphere in the first instance. The transition from the one condition to the other was gradual; the dark lines becoming less conspicuous and finally disappearing as we approached the opposite side of the Volvox to that on which they were most distinct. This specimen illustrates thousands that have been examined, and proves that the *apparent* absence of the cells from so many of the objects is no proof that they do not exist, but merely shows that certain favourable conditions are required to bring them into view. We are justified in concluding that they exist alike in all the specimens of Volvox, and are not merely accidental developments in a few individuals.

In my mounted preparations we obtain further evidence respecting the nature of these two membranes—the protoplasmic and the cellular. We see that the wall of the sphere has an appreciable thickness, the *inner* margin being as definite as the outer one, and nearly parallel with it. Fig. 5 represents this as seen in a section of a Volvox. A moment's inspection of my preparations would convince the most sceptical that such is the case; several of these peripheral cells, as seen in the section, are more highly magnified in figs. 14 and 15. The thin investing pellicle (15 *d*) compresses the outer wall of each cell into conformity with the peripheral curve of the sphere; *laterally* the septa (15 *a*) are straight and parallel to one another. Internally, each cell is a little turgid (15 *a*), the centripetal pressure at this point being obviously at the minimum, and allowing the primary tendency of the cell to assume a spherical form to manifest itself. The green protoplasm adheres firmly to the peripheral wall of each cell, through which the cilia are protruded. Between the true cell-wall and the protoplasm, we have the protoplasmic membrane (14 and 15 *c c'*) in variable conditions. Sometimes it forms an oval cell (14 *c'*), sometimes it is oval at one end and flattened out at the other (14*c*, 15*c'*); at others it is not only flattened out at each extremity and in close opposition with the cell-wall, but even at the two sides (as in the centre cell of fig. 15) the two membranes are closely approximated.

If we turn to a superficial view of the same specimens, we shall obtain similar results. It must be borne in mind that in the living Volvox, even where the cells are visible, we only see the true cells ; the protoplasmic membrane being in such close apposition to its granular and mucilaginous contents as to prevent its being identified as a separate tissue. But when the specimens have been mounted some time, we often find that a change takes place. The protoplasmic matter shrinks up into a small irregular mass (7 *b*), and thus becomes detached from the protoplasmic membrane (7 *c*, *c*') which forms a ring round it. When we succeed in compressing the object so as to force the cells into an oblique position (as is done in those to the left of fig. 7), we see that these circles are really identical with figs. 14 and 15 *c*, *c*' in the sections. The external cells (7 *a*) remain in mutual contact, excepting at their angles.

There is a little discrepancy between this description and that of fig. 11 in my former memoir, and the explanation of its cause will do much to diminish the real difference between myself and Mr. Busk, whilst it tends to confirm my ideas respecting the cellular structure of Volvox. In many of my *mounted* specimens, the outer or *cell*-membranes have either failed to become visible, or have disappeared again. On the other hand, in these examples, the protoplasmic membranes have separated from their protoplasms and become very conspicuous. I formerly confounded the two, and imagined that in the latter examples the incipient separation of the *cells* at the angles (seen in figs. 11 and 16) had been subsequently carried much further, causing a complete isolation of the cells, as is apparently the case in fig. 17. My error was corrected by the specimen delineated in fig. 7, in one part of which *both* these tissues are seen as there represented, thus enabling me to identify the *inner* protoplasmic membranes (7 *c*) of the one with the only membranes seen (17 *c*) in the other. Numerous similar specimens have since confirmed the correctness of this explanation, which clears up many obscure points. I now find no difficulty in recognising the two structures ; the protoplasmic membrane, whether seen in front or in profile, is always more granular, from the adhesion to its inner surface of some of the granular elements of the protoplasm, than is the case with the cell-membrane, the outlines of which are invariably clear and fine. Fig. 8 represents three cells from the same specimen as fig. 7, in which the protoplasmic membranes nearly fill the respective cells ; such specimens, seen in section, exhibit the appearance of the centre cell of fig. 15.

I conclude that if we could bring all these structures into view in a section of a living Volvox, they would present the appearance of fig. 12, where *a* represents the cell-membranes, *b* the protoplasm and its contiguous membranes, *d* the common pellicle, and *e* the prolonged threads of the protoplasm connecting it with the peripheral walls of its cell. Such a section however cannot be obtained until chemical re-agents have rendered the tissues rigid, which process alters their arrangement and aspects.

The entire thickness of the cellular peripheral wall of the Volvox is about 1-1400th of an inch, in specimens that have been a few days mounted in glycerine. The superficial diameter of the cells in the living Volvox varies from 1-800th to 1-1000th of an inch.

The next question relates to the nature of the threads that connect together the protoplasms of the two varieties of Volvox. These cannot be exactly the same in figs. 1 and 10. In fig. 1, the entire protoplasmic mass is drawn out into a stellate form. Each thread consists of the protoplasmic membrane, and a portion of its contents. In fig. 10, on the other hand, the threads contain little or none of the protoplasmic granules, but appear to consist solely of a portion of the membrane. Of course to produce such a result this membrane must be highly ductile, and consequently but partially organized. That the threads are ductile and capable of being drawn out is easily seen on compressing a Volvox between two glasses. The fluid distending the sphere is very viscid and probably consists of mucilage. This must have been secreted by the protoplasms. When we remember that cellulose is but a modified form of gum, we can readily conceive that the conversion of the one into the other may sometimes be imperfectly accomplished amongst these lower forms of vegetation. Such I believe to be the explanation of the ductility of the protoplasmic membrane, and of the threads into which it is drawn out.

Fig. 16 throws a little additional light on this subject. We see from it that whilst the thread sometimes consists of the drawn-out membrane (16 *a*), at others the membrane has receded from the outer cell-wall, leaving only a very faint line, thickened at its peripheral extremity, marking the former point of junction with the outer cell-wall. The same thing is seen in fig. 7. In both these examples the threads were originally of the stellate type seen in fig. 1. Whilst the points of contact with the outer cell-wall are still indicated, they have lost their irregular dichotomous character, and are reduced to straight, radiating, capillary threads, such as are seen in fig. 1. The greater portion of the viscid membrane has receded towards the protoplasm, whilst a small part has in like manner accumulated at the point of attachment to the cell-wall, forming the peripheral dots seen in the above figures; similar appearances present themselves in the other variety, fig. 10. Near the centre of fig. 11, the threads uniting several of the protoplasms have become broken; those which remain have drawn their respective protoplasms towards the sides of the cells to which they are attached. All these circumstances indicate a degree of ductility in the protoplasmic membrane such as would scarcely exist supposing it to consist of perfectly organized cellulose.

In the young gemmæ, as already observed, the protoplasms are in close contact on all their sides; but it is only at a few points that an actual junction is established corresponding with the extremities of the future threads. What has been the eclectic power leading to this result? It is not mere accident. Reference to fig. 11 will show, that in passing from one protoplasm to another these threads always traverse the sides of the hexagonal cells, and never their angles. It is also obvious that these points of adhesion are chosen prior to the development of the outer cell-membrane. This is indicated by the unvarying continuity of the threads when they are single; but still more so when they are double and treble, as is frequently the case (figs. 10 and 11 *e*, *e'*). Whatever the number proceeding from a protoplasm to any one side of its cell, the same number proceeds to the proximate side of the adjoining cell: I have scarcely seen one exception to this rule. I think the explanation just given meets the case; if so, it may be a question whether the cell-membrane is developed between the contiguous extremities of the two protoplasmic threads, or whether it is deficient there, admitting of an actual as well as an apparent continuity. I have already given one or two reasons for believing the former hypothesis; but even should the latter prove the true one, we shall only have recurring in Volvox a phenomenon that is common enough amongst the perforated cells and ducts of the higher plants. In but one instance have I seen a specimen countenancing the latter idea. In it the peripheral layer of cells was very thin and compressed; many of the cells appeared to be wholly detached from each other, as represented in fig. 9; nevertheless the threads proceeded from protoplasm to protoplasm, apparently traversing the intercellular spaces. This specimen is so entirely exceptional as to leave little doubt on my mind that is capable of being explained. I have no doubt that, owing to the thinness of the peripheral cells, a section of it would resemble fig. 13. If we suppose that the circumstances which render the majority of Volvox cells hyaline and invisible, still continue to affect the portions of those in question that are external to the dotted line 13 *f*, the remainder being visible, we should have precisely such an appearance as is presented in fig. 9; the only visible portions of the cells being those which were below the points of mutual contact.

The direction taken by these threads frequently demonstrates the presence of invisible cell-walls midway between two protoplasms. We have already seen that when the threads are liberated their tendency is to become shortened ; hence they pursue the most direct course from one point to another. But we occasionally see examples of what is delineated in fig. 10 *e'*, where two threads run parallel for some distance and then suddenly diverge, proceeding to different protoplasms. This condition obviously indicates the existence of some invisible *point d'appui*, where the divarication occurs. This, doubtless, consists of the hyaline cell-wall. We obtain similar evidence from almost every example of Volvox, when we examine the protoplasms at one margin of the sphere in profile. This can readily be done with object-glasses of short focus, owing to the transparency of the tissues. We very frequently see that the threads, instead of being straight, dip inwards towards the centre of the sphere, and meet at a well-defined angle midway between the two protoplasms, as represented in fig. 12 *e*. This can only be explained in the way just suggested.

Whatever may be the true nature of the objects which I regard as cells, they are obviously separated from the protoplasms before the latter assume their stellate forms, or develop their delicate connecting threads. I have had specimens of every age, from the gemma artificially liberated from the parent sphere, to the hyaline and matured individual, in all of which these cells exist. They are obviously developed immediately after the final process of segmentation has completed the required number of protoplasms ; the development of these cells of the cilia and of the common pellicle apparently taking place about the same time. Names sometimes matter little ; but here they are significant, since they involve the origin of the disputed structure. Mr. Busk regards it as the outer covering of the protoplasm dropsically distended ; I believe that the outer covering (my protoplasmic membrane) remains in close connexion with the viscous protoplasm until the two are separated artificially, and that the cell is a *secretion* from the outer surface of the protoplasmic membrane. According to this explanation, the two bear the same mutual relations as exist between the outer and inner membranes of any other Confervoid cell. The beautiful stellate, spiral, and other forms which the inner membranes of many of these plants assume after their separation from the cell-wall, with which they were primarily in close contact, afford ready illustrations of the similar transformations in Volvox.

The origin of the superficial pellicle (fig. 14 *d* and 15 *d*) remains to be considered. In my last memoir, I stated that each young gemma was developed within a large transparent vesicle (fig. 5 *f* and 6 *f*), which appeared to be the expanded cell-wall of the primary cell (*a*). My more recent investigations confirm this conclusion. When we detach a young gemma and its vesicle from the parent Volvox, the vesicle usually carries away with it a few of the contiguous protoplasms adhering to its outer surface (fig. 6 *b*), indicating the firm adhesion between this vesicle and the walls of the sphere, which we know to exist. This vesicle expands as the gemma increases in size. At first, the latter is closely invested by the former; but when the cilia are developed on the surface of the young organism, the vesicle becomes considerably distended, allowing the gemma to revolve freely within its prison house. (See fig. 5.) At this time the gemma is already invested by its proper superficial pellicle; hence the latter cannot be the modified primary germ-cell, as supposed by Mr. Busk, but is a new growth developed on the surface of the gemma whilst enclosed within the enlarged germ-cell. The source of this pellicle must be sought for in the aggregated protoplasms. It appears to be an independent secretion thrown off by them, in the way that the epidermal cells of a leaf co-operate to produce the similar structureless superficial pellicle. If this be a true homology, it would countenance the opinions of Schleiden and Payen, rather than of Mohl and Henfrey, the latter of whom regards the superficial pellicle as composed of the altered primary walls of pre-existing cells, and not as an external secretion. Henfrey's explanation is that which I applied to the pellicle of Volvox, until the suggestion of Mr. Busk, respecting the primary condition of the volvocine protoplasms, showed me that in this instance the hypothesis was untenable.

The relative periods at which the cells, the superficial pellicle, and the cilia make their appearance is not easily determined. So far as I have been able to form an opinion, I am disposed to think that the cilia first make their appearance, the cells and the outer pellicle being subsequent growths. *A priori*, we should have expected this to be the case, since it would not have been easy for delicate, flexible cilia to force their way through one or two imperforate investing membranes. When the cilia are first produced they are very short, but they gradually lengthen, apparently by additions to the base of each, secreted by the respective protoplasms. After their formation we can readily understand how the pellicle could be secreted from the mass of protoplasms between and round the roots of these cilia, no pellicle being produced where they were attached to the protoplasm. As subsequent additions were made to their length, they would readily push through the apertures so left. After the cilia have fallen off, these apertures can occasionally be seen arranged in pairs, as described in my last memoir. I have, in my cabinet, one specimen in which two large Infusoriæ have been developed within the Volvox, and have apparently eaten away many of the protoplasms without destroying the integrity of the sphere: the cilia have also fallen off: the remaining membranes confirm my previous description of the appearance and relative positions of these apertures.

The fluid with which the sphere is filled is not mere water, but is apparently mucilage. In a preparation in which a number of these objects are mounted in dilute alcohol, this gummy matter has changed to a brown colour, and refused to mingle with the alcohol, as would be the case supposing it to be mucilaginous. This proves that it is a true secretion from the organism, and not merely water absorbed by endosmosis. We may possibly obtain from this source an explanation of the distension of the entire sphere, of the individual cells, and of the vesicles investing the germs. As this gummy secretion increased in quantity, each thin membrane investing the respective protoplasms from which the fluid was derived, would become distended for its reception, as the mere result of internal centrifugal pressure. The secretion itself is, perhaps, little more than a diluted condition of the same gum as that which is more or less completely converted into cellulose in the various investing membranes just enumerated.

I cannot but think that the details now brought forward, resulting from a careful re-examination of the entire subject, will convince every unbiassed observer of the general accuracy of my previous conclusions, and especially those relating to the cellular structure of the walls of the sphere. In the memoir in which these conclusions were recorded, I pointed out the close analogy that existed between the development of Volvox and that of many of the lower Algæ and Confervæ. I also referred to the obvious resemblance of each protoplasm to the well-known Zoospores.

It is only whilst the segmentation of the gemmæ is in progress that a real relation exists between Volvox and young growing Confervæ. At a later period every segment of the former becomes converted into a Zoospore: each Zoospore, in turn, having the power to cast off its cilia, and go through a new process of segmentation, in precisely the same way as the Zoospores of a Conferva or a Vaucheria. Only a few in each Volvox are selected for this purpose, but the potentiality doubtless resides in all. The cell-walls in the Volvox resemble the cells in which the Confervoid Zoospores are developed, the only essential difference being, that in the former instance the cilia penetrate the cell-wall, instead of being retained within it, and the germination is carried on whilst the Zoospores maintain their connexion with the parent sphere, instead of being previously detached from it.

All the facts brought to light by this inquiry confirm my previous conclusion (which conclusion receives, also, the effective support of Mr. Busk), that the affinities of Volvox are with the vegetable, and not with the animal kingdom.

Since the above memoir was laid before the Society, Mr. Busk has supplied me with specimens of *Volvox stellatus.* I quite agree with him in his view that *V. stellatus*, *V. globator*, and *V. aureus* are mere varieties of one species. In his specimens of *V. stellatus* the protoplasms were of the stellate form of fig. 1. *The investing cells were obviously present in all the examples which I examined.* The above generalisation by Mr. Busk does away with the possibility of the brilliant granules of the protoplasm being spores, and leads to the probability that the curious bodies either in *V. stellatus* or *V. aureus* are the true winter spores. In *V. stellatus* I have noticed that the ordinary power of gemmation appears to have worn itself out; since, though the gemmæ often co-exist with the spores (?), they are small, colourless, and abortive. The curious stellate investments of the spores (?) of *V. stellatus* appear to me to be homologous with my vesicles (fig. 5 *f*), within which the true gemmæ are developed, and consequently to be the modified primary germ-cells. These often exist without the stellate protuberances, when their resemblance to the vesicles of the gemmæ is very obvious. In the pond from which I chiefly obtained my specimens this year, they were all of the type represented in fig. 10. This was their character in April. In the beginning of September, all traces of the connecting threads had disappeared, each protoplasm then resembling my fig. 4. At the close of September nearly all the Volvoces disappeared. In the few that remained, the protoplasms had reverted to the stellate type of fig. 1.

On the Application of PHOTOGRAPHY *to the Representation of Microscopic Objects.* By JOSEPH DELVES, Esq. Communicated by Mr. Bowerbank. (Read Oct. 27, 1852.)

AT the present time, when the microscope is contributing valuable aid in nearly every department of science, and its uses as an instrument are more generally known, it becomes of the greatest importance to possess some method more truthful than those hitherto adopted for copying the beautiful images of the achromatic object-glass.

The recent discoveries in photography render its application to the microscope a subject for much consideration, since only by its assistance can we hope to obtain trustworthy impressions of objects so delicate and minute. I would, therefore, beg to submit to the consideration of the Society the method I have adopted for producing these copies; and as an illustration of the successful application of Photography to the microscope, I have the honour of presenting the specimens which I have recently obtained.

I must, however, beg to state that others have an earlier claim than myself to this application; but with so little success had it previously been carried out, that I believe I am correct in saying it has been generally abandoned as a means of depicting microscopic objects. But for the satisfactory result it is only necessary to refer to plate VII.

The only arrangement necessary for the purpose is the addition to the microscope of a dark chamber, similar to that of the camera obscura, having at one end an aperture for the insertion of the eye-piece end of the compound body, and at the other a groove for carrying the ground-glass plate.

This dark chamber should not exceed 24 inches in length (the size which I have found best to adopt): if extended beyond this, the pencil of light transmitted by the object-glass is diffused over too large a surface, and a faint and unsatisfactory picture is the result. The specimens exhibited were taken at this distance, which has the additional advantage of producing a picture, in size very nearly equal to the object as seen in the microscope. The eye-piece must be removed from the compound body, and the object (being well illuminated by reflection from the concave mirror) must be adjusted and focused upon the ground-glass plate. In the production of positive pictures a slight difficulty here arises, dependent upon the "over-correction" of the object-glass. The effect of this "over-correction" is to project the blue rays of light beyond the other rays of the spectrum, and as the chemical properties of light reside in the violet and blue rays, it becomes necessary that the plane of the sensitive plate should coincide with the foci of these rays, and it must therefore be placed beyond the surface at which the best definition is seen; this amounts to some distance with the lower combinations, and decreases with the increase of magnifying power.

For the production of *negative* pictures the ordinary illumination is not sufficient, and recourse must be had to the sunbeam, which should be reflected upon the object by the plane mirror when powers are used not exceeding the quarter of an inch combination. It is not necessary here (when producing negatives by the sunbeam) to allow for the "over-correction" of the object-glass, but merely to focus the object carefully upon the ground-glass plate.

With regard to the time required for the production of these photographs, unfortunately no precise rules can be given, since it must vary with the sensitiveness of the materials employed. The larger group exhibited was produced by the "1 inch object-glass," and the time given varied from ten seconds to one minute. The smaller group, representing "scales of Lepisma saccharina by the quarter inch and one-eight inch glasses, was taken with a more sensitive collodion; and the time from ten to fifteen seconds."

In the production of negative pictures (from which the paper specimens were obtained) a moment's exposure to the sunbeam is sufficient when using the lowest powers, and with the highest I have varied the time from five to ten seconds.

In conclusion, I beg to submit this method which I have found so simple and successful, in the hope that the communication may be the means of directing attention to a subject both useful and interesting, and in the confidence that most satisfactory results will yet be obtained.

Some Observations on the Structure of the Starch-Granule. By Geo. Busk, Esq., F.R.S. (Read Dec. 29, 1852.)

"No substance has been more investigated, and yet of which there is less known, than starch. After the researches of ten years, in the course of which the most various views have been propounded on the nature of starch, and after all its characteristics as a proximate vegetable substance have been discussed, we are little or nothing in advance of the old point of view; and although we may, perhaps, not be wholly without some addition to our knowledge in secondary points, we are still entirely without any sound reasons to suppose that we have arrived at the truth."

This passage, from Poggendorff's Annal., 1837, vol. xxxii.

is quoted by Professor Schleiden, writing eight years afterwards,* and he adds that these eight years, notwithstanding the publication of innumerable works by chemists and vegetable physiologists, had been equally thrown away in the investigation of this important vegetable element; but, strangely enough, asserting that this unsatisfactory result had arisen solely in consequence of neglect, or from superficial microscopic examinations.

If our knowledge respecting the structure of the starch-grain were thus unsatisfactory in 1844, it can scarcely be said to have been much enlarged since, notwithstanding the investigations of the learned and eminent Professor himself; and to which investigations—whatever he may be inclined to think or express with respect to the labours of others—he would not be the last to resent the imputation of superficiality.

We cannot but believe that a subject, which has thus baffled the endeavours of so many and such competent inquirers, must possess some inherent difficulty, for, in 1851, we find Dr. A. Braun,† one of the most accurate and acute of recent vegetable physiologists, still lamenting, in the same terms as Schleiden, the want of accurate knowledge on the subject of the origin, formation, and structure of starch, which he is of opinion demands a new and careful investigation, seeing that none of the views set up are sufficiently based upon direct observation.

Having lately been incidentally led to the investigation of the structure of the starch-granule, I have thought the results might be interesting to the Society, although they cannot be said to be altogether novel.

In the numerous and very different modes in which it has been attempted to explain the structure of the starch-granule, only two really and essentially distinct views seem to be expressed. "These views," as Schleiden observes, "are decidedly opposed to each other, and on the assumption or rejection of them, the chemical judgment passed upon this substance must essentially depend."

1. According to the one view the starch-granule is a vesicular body, the wall of which differs, at all events in consistence, if not in chemical constitution from the contents.

2. In the other view the granule is considered as a solid body, constituted either of a homogeneous substance, or composed of concentric layers, deposited, according to one set of observers, around a *nucleus*, either differing in its chemical

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* 'Principles of Scientific Botany.' Translated by Dr. Lankester. 1849. p. 19.

† 'Betrachtungen üb. d. Erscheinung der Verjüngung in der Natur.' 1851.

nature from the layers around it (Fritsche), or not essentially different in that respect (Endlicher and Unger). Schleiden, on the other hand, and many other observers, look upon the supposed nucleus as a minute cavity or indentation. Dr. A. Braun (*l. c.*), however, supposes that this cavity does not exist originally in the granule, but that it is of a secondary nature, arising in the disappearance of the nucleus.

The laminated, or supposed laminated, appearance evident in many forms of starch, and demonstrable perhaps in many others by means of polarized light, has been variously explained according to the above views of the essential constitution of the granules.

In accordance with the former of these views, Münter,* Nägeli,† and Link, suppose that the laminæ are formed by an internal or centripetal deposition of matter in the interior of the cell, and, according to the latter, this deposition is conceived to take place from without, or, as it may be expressed, centrifugally. This notion appears to be that more generally adopted. Originally propounded by Fritsche, it is followed by Schleiden, and, more recently also, though with some hesitation, by Dr. A. Braun (*l. c.*) who considers it as much more probable than that advocated by Münter and Nägeli, if the starch-grains are not themselves cells, but merely the product of secretion from the cell-contents, in the same way as the cell-membrane is, with which the starch is so closely allied. The same view is also adopted by Focke‡ and Schacht.§

The above is a very brief and imperfect summary of the views more generally entertained on the structure of starch, and, omitting all reference to what has been written respecting its mode of origin (which, in fact, amounts to little) and its use in the vegetable economy, I will now proceed to notice what may be termed a modification of the former of the above described views, or of that which assigns a cellular structure to the starch-granule, and the reception of which I am greatly inclined, from my own observations, to advocate.

Leeuwenhoeck,‖ to whom we are indebted for the earliest notice of starch-granules, enters with considerable minuteness into a description of those of several plants, such as wheat, barley, rye, oats, peas, beans, kidney beans, buckwheat, maize, and rice, and very distinctly describes experiments made by

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* Münter, 'Ub. das Amylon der Gloriosa superba,' &c. ('Bot. Zeit.' 1845, p. 198.)

† Nägeli, 'Zeitschrift.' 1847, p. 117.

‡ Focke, 'Die Krankheit der Kartoffeln.' Taf. ii. fig. 13, f. g. h.

§ Schacht, 'Die Pflanzenzelle.' 1852, p. 41.

‖ Leeuwenhoeck, 'Epistolæ Physiologicæ,' &c. Delphis. 1719, p. 236.

him in order to investigate the structure of the starch-granule. He placed a certain number of the grains upon a clean piece of glass, and added a minute drop of water, and, upon the grains thus separated from each other, he placed two more drops of water. The water was then dissipated by the application of heat for about a minute. He then noticed that the starch-granules had lost their rotundity and degenerated into plane figures of unequal size. From this experiment he concluded that the starch-grains of wheat, and other plants examined by him, were covered, like the wheat-grains themselves, by a cuticle. And he imagined that the incurvation of the starch-granule took place at that part only, where the cuticle, not being continuous, was joined by a sort of commissure—whence, he conceived it arose, that the granules, being heated and moistened, dehisced, and sank down into a flat form. He gives numerous figures of various sorts of starch in different stages, from partial expansion to complete evolution.

We have here apparently the basis of the cellular hypothesis of starch, afterwards more fully developed by Raspail and others. Leeuwenhoeck, however, does not appear to have regarded the contents of the starch-cell as fluid; and in this he was obviously more correct than his modern followers. But as Raspail's view, in its integrity, is no longer maintained, I believe, by any one, having been long ago given up even by his more immediate followers, and particularly by Payen and Persoz, it is needless further to advert to it. The later modification also of it advocated by Münter and Nägeli, though with more scientific pretensions, is still so diametrically opposed to what may perhaps now be considered the correct doctrine of vegetable cell-formation, as in my opinion to be totally inadmissible.

Following in the footsteps of Leeuwenhoeck, Dr. S. Reissek* attempts to deduce the cell-nature of the amylum-granules from the phenomena presented during their decay or dissolution, when left for some time in water. He says that, "owing to the solution and exosmosis of their internal and more solid substance (in contradiction to Schleiden and Münter), they become hollow, so that of the entire starch-granule only the outermost layer remains, which, having become soft and flexible, assumes the appearance of a closed sacculus, that is, of a cell." He therefore regards the amylum-granule as a perfect cell.

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* Reissek, Haidinger's 'Berichten üb. d. Mittheil. von Freunden d. Naturwissen. in Wien.' Mai—Oct. 1846. Wien, 1847, p. 84.

M. Guibourt * says that the internal portion of the starch-grain breaks up in the form of flocculi, whilst the outer portion, the membrane, is lacerable, and occasionally exhibits the form of an empty pouch.

The expansion and alteration in form of the starch-grain, under the influence of heat and of sulphuric acid and other re-agents, is a fact recognised also by Schleiden and those who adopt the view of its solid or homogeneous nature; it is, in fact, so obvious a phenomenon that it could not possibly escape observation. They, however, and I believe nearly all who have adopted the cellular hypothesis, consider this to be owing simply to the expansion of the solid body or vesicle. Till very recently, Leeuwenhoeck only appears to have attributed this increase in size and change of form of the granule, not to a mere expansion, but to an opening out of the granule on one side, or to its evolution in other words, whence it assumes a flattened figure, and of course an increase in apparent diameter. Although not, in the precise sense, understood by Leeuwenhoeck, I believe that his notion, with some correction, represents more nearly the true doctrine of the structure of the starch-granule than that of any of his successors till a very recent period.

In the Philosophical Magazine for April last is a paper 'On the Amylum Grains of the Potato,' by A. G. C. Martin, Librarian of the Imperial Polytechnic Institute of Vienna, which appears to me to contain the germs at all events of a correct doctrine with respect to starch; and as I was led to pretty nearly the same conclusions as himself, though from experiments of a different kind and instituted for a different purpose, I have the more confidence in his results. And as the procedure I was led, more accidentally than otherwise, to adopt is perfectly easy and simple, this paper may at all events serve to incite others to repeat the experiments, and thus we may hope that the *vexata quæstio* of the structure of starch may in some degree be set at rest. M. Martin's mode of experimenting is nearly as possible the same as that adopted by the illustrious Leeuwenhoeck, and his results are not in the main very dissimilar.

As the observed results at which M. Martin and myself have arrived in the examination of potato starch appear to coincide in every particular, it is obvious that the reasoning applied to his is equally applicable to mine. These results have in both cases been arrived at by noticing the phenomena which take place in the amylum-granule *during* its expansion, and

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* 'Journal de Pharmacie.' 1846, p. 191.

not when it has nearly or completely terminated.* This expansion or dissection of the granule is effected by M. Martin by means of heat applied in an ingenious but still inconvenient way, while the object is under the microscope. He thus employs it:—

"Between two very thin glasses, of the same size as the stage of the microscope, a little amylum, with a sufficient quantity of water, is to be put, and the former well spread out with the finger, to prevent as much as possible the formation of bubbles. The number of amylum grains in the field of view should not exceed ten or fifteen. The glasses should lie freely on the spring-piece, which must be raised by means of two pieces of cork introduced below it, so that while the two glasses are lying right upon the object-bearer, a current of cold air will ascend from below, or permit the little flame to continue burning in the hole of or below the stage. As the glasses are wide, they protect the microscope from too great a heat or other danger. The small flame is to be obtained from a common thread, doubled and slightly waxed. This, when ignited, gives a flame quite sufficient to boil the amylum."

In the course of his experiments he discovered that the slightly iodizing of the starch-grains delayed, so to speak, the entire process of boiling, and rendered the result more certain and satisfactory, and he states that his process seems to succeed still better in a concentrated solution of alum, with as much tincture of iodine as will colour the grains of a steel blue.

The same benefit arises also in my process from the addition of as much iodine as will render the starch a pale blue without destroying its transparency; and the use of iodine in either case is attended with the further advantage that it renders the starch in its subsequently changed condition much more visible than it otherwise would be.

Instead of heat I employ concentrated sulphuric acid, and in the following way:—A small quantity of the starch to be examined is placed upon a slip of glass and covered with five or six drops of water, in which it is well stirred about, and with the point of a slender glass rod the smallest possible quantity of solution of iodine is applied, which is to be quickly and well mixed with the starch and water. As much of the latter as may be must be allowed to drain off, leaving the moistened starch behind, or a portion of it is to be removed by inclination of the glass, and the starch is then to be covered with a piece of thin glass. The object must then be placed in the

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* *Vide* Observations on the Structure of the Starch-granule in a paper on Valisneria spiralis, by E. J. Quekett, published in the third number of the 'London Physiological Journal' in 1844.

microscope, and the object-glass ($\frac{1}{4}$ or $\frac{1}{5}$) brought to a focus close to the upper edge of the piece of thin glass. With a slender glass rod, a small drop of *strong* sulphuric acid is to be carefully placed immediately upon, or rather above the edge of the cover; care being taken that it does not run over it. The acid of course quickly insinuates itself between the glasses, and its course may be traced by the rapid change in the appearance of the starch-granules with which it comes in contact. The course of the acid is to be followed by moving the object upwards, and when, from its diffusion, the re-agent begins to act more slowly, the peculiar changes in the starch-granules, now also less rapid, may be readily witnessed.

These changes in potato-starch are thus described by M. Martin.* "First, the amylum grain sinks in, in that place, where, according to Fritsche, the kernel (nucleus) is situated. On the surface minute fissures appear, two of which almost regularly diverge towards the thicker end of the grain. The grain continues to be depressed inwards until a cavity is formed which is surrounded by an elevated ridge. In proportion as the grain swells up, this ridge increases in circumference and decreases in breadth, that is, continues to get flatter until fissures, mostly of a stellated form, appear in the hitherto little altered thicker part of the grain. The process is not very rapidly developed, and it is very difficult for the eye to follow it. Suddenly something is torn off, the grain is extended lengthways, and in the next moment a wrinkled skin of a rounded, generally oval shape, lies on the glass. Middle sized and small grains exhibit this shape most distinctly; and they have usually only one longitudinal wrinkle, the upper and lower ends of which are pointed. The constant appearance of this wrinkle is important for the development of my theory. The appearance of this disc," he goes on to say, "demonstrates that it is *perfectly flat*, and has a slightly elevated edge which also becomes flat on pressure. The contour is rounded, but perfectly sharp. If the two glasses be violently moved from one side to the other whilst pressing the amylum, the disc is torn, and it is distinctly seen, especially in the blue-coloured ones, to consist of two layers, an upper and a lower one. Further examination shows that they are collapsed vesicular bodies, consisting of an extremely fine but strong and elastic membrane."

"The primary form, therefore, of the amylum grain," according to M. Martin, "is a spherical or ovate vesicle. If this be considered as empty, and so contracted that one-half

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* L. c., p. 279.

lies in the other half, a watch-glass shaped basin is formed, which after boiling and pressure between the two glasses, appears, in consequence of the delicacy and elasticity of the membrane, as a flat, round-edged disc."

According to him, it follows, that the starch-granule, in its more usual form at least, is formed by the inrolling upon itself of this spherical or ovate vesicle. It is not very easy, at all events I do not find it so, to comprehend M. Martin's explanation of the mode in which this inrolling or involution takes place, nor have my own observations as yet enabled me to express a very decided opinion with respect to this point. The appearances exhibited in the microscope, under the action of strong sulphuric acid, convey the idea rather of an unfolding of plaits or rugæ, which have, as it were, in some kinds of starch (those with a long fissure-like or stellate hilum especially) been tucked in towards the centre of the starch grain, than of the unwinding of rolls. And I conceive that the apparent laminæ are nothing more than the indications of the edges of such plicæ or folds in the contracted state, upon which I shall say a few words presently. The starch-grain of the horse-chestnut perhaps affords as good an example as any, and one readily obtainable, of the appearances which might be supposed to arise were the constitution of the granule such as I have just described; that is, as far as the tucking in of the vesicle towards the centre is concerned, because in this grain I am not aware that the concentrically laminated appearance arising from folds of the vesicle is evident. Fig. 10, Pl. VIII., represents the usual forms and aspect of the unaltered starch of this fruit, and figs. 11, 12, 13, various granules in different stages of evolution under the use of strong sulphuric acid.

If it be allowed that the starch-vesicle, as the ultimate product of the evolution of the grain might perhaps be termed, be elastic—which, in all probability, it is—it is easy to understand, as in fact is pointed out by M. Martin, that the portions which are folded into the interior must be more or less compressed, and thence denser; in consequence of which inequality of tension the phenomena exhibited under polarised light might be explained. I have examined several varieties of starch, such, for instance, as of the Potato; the Arrow-root termed "Tous les mois," which is, I believe, afforded by a species of Canna; two other kinds of arrow-root; the starch of the Spanish Chestnut; of the Yam; of a species of *Curcuma*, which seems to be identical with East Indian arrow-root; of *Cycas circinalis; Zamia integrifolia; Arum maculatum*, and what is termed Tacca arrow-root; and find more or less distinctly in all, indications of a similar structure, differently modified, however, in some respects, in each. Upon referring, moreover, to the figures of different kinds of starch given in Schleiden's 'Botany,' before quoted, a tolerably complete series of development, as it may be termed, of different forms of starch, will, I think, be sufficiently obvious. Fig. 13 of Schleiden, representing starch-grains from the rhizome of *Anatherum iwarancusa*,* and fig. 8 those of *Iris pallida*, show, as I conceive, the simplest form of inversion or folding of the edges of the starch-vesicle. A further stage is apparent in fig. 12, the starch of *Colchicum autumnale;* and a further advance may be traced in fig. 14, the starch-granules of *Arum maculatum*, whence the transition to the form presented by the starch of the horse-chesnut is sufficiently clear, and from these more or less open forms to the complete involution seen in the potato-starch, &c.

The dissection of the starch-grain may be effected in several ways besides those I have noticed, and equally, if not more, conveniently. And as the dissection effected in any of these modes appears to yield the same result, the latter may be regarded perhaps as the more worthy of confidence.

I have usually selected for my experiments the form of arrow-root called "Tous les mois." It is a favourable subject for investigation, owing to its large size and regular conformation, as seen in figs. 1, 2, 3, 4, 5. The grains of Tous les mois are of various sizes and of different shapes,—some oval, some more expanded, with a sort of horn or shoulder on each side, or on one side only. The grains, like those of most kinds of starch, are not cylindrical, but flattened, and towards one end of each grain is a minute circular spot, the area of which appears granular; and concentric to this spot the surface of the grain—or rather one of the flat surfaces only and the sides—is marked with delicate concentric rings. It is these rings which have been described as indicating a laminated structure, and, consequently, corresponding lines or planes should be seen, under favourable circumstances, passing through the substance. This appearance has actually been described as existing by Schleiden and others, but I have looked for it in vain, and Mr. Quekett, in his Lectures on Histology, describes the markings as superficial. His expressions, moreover, would plainly imply that this accurate observer entertains an opinion with respect to the structure of the starch-grain pretty nearly if not quite identical with that advocated in this paper, and that, as I suppose, the lines indicate the rugæ or folds into which the starch-vesicle is

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* Munter, however, denies the existence of starch-granules like those figured by Schleiden in the rhizome of *A. iwarancusa*.

thrown in the contracted state, and that this is the case seems to be shown by the immediate effects of re-agents. The first change, after a slight swelling of the starch-grain, consists in the appearance of minute transparent elevations around the edge of the grain, as shown in fig. 6, each of which, I conceive, represents the edge of a fold or ruga ; a further stage of expansion is shown in fig. 7, and a still farther one in fig. 8 ; whilst the full expansion of the vesicle in Tous les mois is shown in fig. 9. I believe, also—but of this I would speak very doubtfully — that each starch-vesicle has an opening which corresponds with the central spot or hilum. With respect to the contents of the vesicle, some appearances lead me to suppose that, occasionally at all events, it contains a flocculent or grumous material—amorphous starch, which is equally coloured by iodine, as is the wall itself of the vesicle. There is sometimes also an appearance of a transparent colourless wall around these grumous contents, in a form of arrow-root I have examined; but an outline of this kind is often a very deceptive phenomenon, and I do not wish to be understood positively to assert its existence even in the case alluded to.

Two additional modes, which I have found convenient in the examination of starch, consist:—1st. In the previous roasting of the grain till it acquires a light-brown colour, and is, in fact, converted into British gum ; while in this state, if it be moistened with a very weak solution of iodine, the grain gradually unfolds itself in the most beautiful manner. 2. The iodized solution of chloride of zinc, proposed by Professor Schultz, may also be very advantageously employed. This solution, if quite concentrated, does not at first colour the starch at all, but, on the addition of a little water, the blue colour is elicited, and the starch-grains gradually swell out and evolve themselves in the same way as they do under the previously described treatment. I make the iodized solution of chloride of zinc by dissolving 1 ounce of fused chloride of zinc in about half an ounce of water, and adding to the solution (which amounts to about an ounce fluid measure) 3 grains of iodine dissolved, with the aid of 6 grains of iodide of potassium, in the smallest possible quantity of water.

Since the above paper was read, I have noticed appearances in the amylaceous corpuscles which occur in the wall of the primordial utricle of *Hydrodictyon utriculatum*, which lead to the opinion that the starch—in this case at least, and probably in all the similar forms and situations in which it occurs in the lower Confervæ, &c.—is deposited around a nitrogenous nucleus. In *Hydrodictyon* the fact is very clear, that the central portion of the amylon-corpuscle is turned of a deep brown by iodine, or pink, by sulphuric acid and sugar (as was first pointed out to me by Mr. Huxley), and that at one time it exhibits no trace of starch in its composition, but that subsequently this nitrogenous nucleus becomes surrounded, not with an entire wall of starch, but apparently by a cup-shaped deposit of that substance in which the nucleus lies imbedded, or from which it projects on the external aspect. Further observation of this and analogous phenomena may perhaps in time lead to a more satisfactory explanation of the genesis of starch than can at present possibly be given. It does not, at all events, contradict the notion of the vesicular nature of the starch-grain, but rather, as it seems to me, tends to confirm it; for we have only to imagine the entire removal—as we may often witness the partial—of the central nucleus, when what remains, viz. the cup in which it was lodged, will very closely resemble some of the more open forms of starch-vesicles I have noticed in the paper.

On the Stellate Bodies occurring in the Cells of FRESH-WATER ALGÆ. By the Rev. WILLIAM SMITH, F.L.S.

The third volume of the 'Transactions of the Microscopical Society,' containing, at p. 165, *et seq.*, two papers by G. Shadbolt, Esq., 'On the Sporangia of some of the Filamentous Fresh-water Algæ,' has just been placed in my hands.

The subject discussed in these papers having attracted my attention at various times, and being in possession of additional facts, some corroborative of Mr. Shadbolt's statements, and others which lead me to a conclusion widely different from that to which he has arrived, I have gladly embraced the opportunity, which the Society has accorded me, of bringing the following details under the attention of its members:—

The accurate observations of one of the earliest and most successful students of this department of botany, M. Vaucher, of Geneva, have established the correct nature of the oval body, formed by conjugation in the filamentous Algæ, which this author has shown to be a true spore, each such body, formed by the union of two cells, giving birth, upon germination, to *a single cell*, which subsequently, by the ordinary method of self-division, becomes elongated into a filament ('Histoire des Conferves d'Eau douce,' Geneva, 1803, p. 66, *et seq.*, Pl. IV. 5, V. 3, VI. 4). I have been able, by personal observation, fully to confirm the observations of M. Vaucher in reference to one species of the *Conjugatæ* ('Ann. Nat. History,' 2d S., vol. viii., p. 480), and have no hesitation in accepting the facts as of general import in reference to the entire family. I have alluded to the circumstance, not only as having a direct bearing upon the subject of this paper, but also that I may explain my reason for not employing the term "Sporangium" in reference to the bodies in question, it being evident that this designation is not applicable to a body which is in itself a *single* germ.

With regard to the stellate bodies to which your attention is now more particularly requested, their true character being for the present doubtful, it will be better to employ a designation which does not involve any reference to their nature, and has regard merely to their form, I shall therefore speak of them as *Asteridia*, their general appearance being that of circular, star-like bodies.

The presence of *asteridia* is by no means confined to the family of the *Conjugatæ*. I have frequently noticed them in the *Desmidieæ*, and occasionally in the *Diatomaceæ*, though in these tribes the presence of spinous processes is by no means a constant character. I have always found (and Mr. Shadbolt's experience seems to be confirmatory, *l. c.*, p. 166) that, if present in a gathering when first made, the numbers of *asteridia* rapidly increased when the *Algæ* were retained in vessels for future examination, and as more or less of change and decay almost invariably attends the attempt to preserve such organisms in a limited space, and removed from their natural habitats, I have hitherto regarded the presence of *asteridia* as indicative of disease, as being, in fact, a parasitic, perhaps a fungoid growth, consequent upon the degeneration of the cell-contents.

I am not prepared to put forward this as the true character of *asteridia*, but I am prepared to dispute a view of their nature which confounds them with the reproductive germs, and shall proceed briefly to state the reasons why such a character and function are altogether inadmissible.

It is well known that conjugation in the *Algæ* implies the union of the *entire* contents of two cells, which contents intermix and become condensed into the reproductive spore, and that this union is effected by the amalgamation of the contents of two contiguous cells in the same filament, or by the same process occurring in two cells belonging to different filaments. The mode in which this amalgamation takes place is either by the breaking down of the walls at the contiguous extremities of the cells, as in the *Vesiculiferæ*, or by the production of connecting tubes, which form channels of communication between the conjugating cells, whether in the same or different filaments. These connecting tubes are shown in the drawings which accompany this paper, Pl. IX., fig. 2 *b*, fig. 4 *b*, &c.: and it is worthy of notice that, although one mode of effecting the union of the cells seems to be pretty general in the same *Alga*, it is by no means constant, as tubes connecting contiguous cells of the same filament, or uniting apposed cells of different filaments, will be found in connexion with the same species: an example is given in fig. 6.*

Now it will be seen by a reference to the figures I have given, and more particularly to figs. 4, 5, 6, which are drawn with the camera lucida from mounted specimens of *Zygnema quadratum* kindly supplied by Mr. Shadbolt himself, that the circumstances, as stated above, which accompany the process of conjugation, altogether negative the opinion that the *asteridia* are products of such a process, as the cells containing these bodies always contain with them a portion of the original endochrome or cell-contents, which must have been *entirely* absorbed had conjugation been effected. Nor are there, in any case, to be found the connecting tubes which are necessary to the process in the species we have selected. It is, therefore, evident that the *asteridia* are not modified or matured spores, as the cells containing them have not undergone the process necessary to the formation of the reproductive body.

An inspection of fig. 1 will also show the incorrectness of the conclusion to which Mr. Shadbolt has arrived, viz., that the *asteridia* are spores in a more advanced stage. We have here a portion of a filament of *Zygnema quininum*, in the cells of which the gradual formation of the *asteridia* may be distinctly traced. Cell *a* presents the ordinary and healthy appearance of the plant; in cell *b* degeneration has commenced, and a faint appearance of several aggregations of the cell-contents may be detected; these aggregations in cell *c* assume the character of perfect *asteridia*, which in cell *d* are no longer in contact with the endochrome, among which they have been generated. But in no case do we perceive any

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* This fact throws some doubt upon the propriety of placing (as Kützing has done in his genus *Rhynchonema*, and Hassall in a sub-genus) species, which conjugate by tubes connecting contiguous cells, apart from those in which the conjugation takes place between cells in different filaments.

semblance of the process of conjugation, or of that mingling of the contents of different cells so essential to this function of vegetable life; and instead of only one body, which is the invariable result of the conjugating process between two cells, we have each cell containing several *asteridia*, the number of which I have noticed to vary from two to six in a single cell.

Figs. 2 and 3, which are drawn from specimens supplied by R. Hodgson, Esq., exhibit phenomena which are equally irreconcilable with the hypothesis I controvert. These sketches represent portions of filaments of *Mesocarpus scalaris.* In this species the reproductive spore is lodged in the inflated tubes which connect the conjugating cells, while the *asteridia*, which were exceedingly numerous in the specimens I examined, were invariably contained in cells from which no connecting tubes had been projected. To the above considerations let me add the fact already referred to, viz. that germination has in several species of the *Conjugatæ* been observed to take place in the oval or elliptical spore which results from the process of conjugation, without any previous change in the form of this body.

The figures, given in the plate which accompany Mr. Shadbolt's paper, bear out to their fullest extent the facts I have now stated, and might, indeed, have sufficed as illustrations of my views had I not been desirous of giving as many examples as possible of a singular, and far from common, monstrosity, in a curious and interesting class of plants; but I cannot forbear calling attention more particularly to Mr. Shadbolt's fig. 4.

This drawing, which represents *Lyngbya floccosa* with *asteridia*, is surely sufficient to prove that such bodies have no essential connexion with the reproductive spore, for in this case there are no traces whatever of the conjugating process, and each cell, whether with or without *asteridia*, has its full proportion of endochrome, though in a disturbed and degenerate condition, the breaking down of the cell-walls in the neighbourhood of the *asteridia* being a further evidence of the diseased condition of the filament. On the whole, while I feel unable to assign a positive character to these singular parasites, I feel no difficulty in withholding from them the important office ascribed to them by the gentleman upon whose communication I have commented. The writer of that paper will allow me to thank him for the interest he has excited in a subject which has long caused me no little perplexity, and for the very lucid manner in which he has stated his opinions.

Lewes, Jan. 12, 1853.

NOTE.—Since the above was read before the Society, I have met with a brief notice of the Stellate Bodies, to which this paper refers, in a communication from Mr. G. H. K. Thwaites to the 'Annals of Natural History,' vol. xvii. p. 262, and dated March 19, 1846. It is satisfactory to find that the observations and conclusions of this eminent algologist coincide, as far as they extend, with mine. Mr. Thwaites asks whether the stellate bodies in the cells of *Mesocarpus scalaris* may not be an abnormal growth of the nucleus, or perhaps an internal parasite; describes them as formed from a small spherical cell, containing an oily-looking fluid; and states, as I have done, that they are not developed, in the manner of spores, at the expense of the endochrome of the cells which contain them.—W. S.

On the Presence of a FUNGUS *and of Masses of* CRYSTALLINE MATTER *in the Interior of a living* OAK TREE. By JOHN QUEKETT, Resident Conservator of the Museum and Professor of Histology to the Royal College of Surgeons of England. (Read January 26, 1853.)

IN the month of August of the past year I formed one of a pic-nic party to visit the well known King Oak, in Marlborough forest. The day was stormy at intervals, but there was little or no wind. Whilst we were all assembled under a large ornamental shed, erected for the convenience of visitors to this much-frequented spot, a sudden loud snapping noise was heard, which was followed by a still louder crash of broken timber. This we found was not occasioned (as we first imagined) by the fall of a lofty oak, but, as it subsequently turned out, of only a large limb. Our fears at the moment were greatly excited lest this fall might have been occasioned by one of the junior members of our party swinging on the limb, but it appeared that he had climbed into the interior of the King Oak, and, looking out of a hole, was the nearest spectator of the accident; his attention having been directed to it by the noise of the snapping of wood, and the crash produced by the fracture of the branches of numerous trees in the neighbourhood, upon which the limb in question fell.

As soon as our fears were allayed by knowing that our young friend was safe, some of the more venturesome of the party, myself amongst the rest, sallied forth to see what had happened. We found that the King Oak was uninjured, but that a tree about fifty yards from it, and of very large size, had lost one of its finest limbs, and some idea may be formed of the size of it when I tell you that, at the fractured part, it was nearly three feet in diameter, and its length, to the first bifurcation, just twenty-seven paces. On examining the fractured surface, I was surprised to perceive that in the very centre there was a white flocculent mass, about a foot in diameter, which at once reminded me forcibly of the appearance presented by a thin layer of cotton wool cemented to the surface of wood by gum or glue. I looked at it very carefully, and considered that it must be a filamentous fungus; and, on examining it with my pocket-glass, I distinctly saw some sparkling crystals amongst the filaments; some of these were very minute, others sufficiently large to be visible to the naked eye. The wood, at a cursory glance, appeared perfectly sound, was very moist from the quantity of sap present, and had a powerful acid smell, like that of vinegar, which was very perceptible on approaching the fractured portion. Having satisfied myself of the presence of a fungus, I turned my attention to the examination of the fractured surfaces, both of the tree itself and of the limb, and I could discover no hole or trace of a hole, or any dead wood leading from the circumference to the centre, either of the tree or of the limb, but still there was a peculiar appearance in those parts of the wood itself near the white filamentous mass above-mentioned, which was due to the separation of those woody fibres, that were involved in the fracture. This appearance is still present in a specimen of wood I brought away at the time, but which has now become hard and dry. All its surfaces exhibit a very remarkable kind of roughness different from that of any oak wood that has been split by artificial means, and I have tried in vain to get a surface at all like it by splitting. Having removed as much of the wood covered with the white mass as I well could with the aid of a pocket-knife, I took it home for microscopical examination, and the structure most commonly exhibited is that shown in fig. 7, pl. IX. The woody fibres were much separated in parts, and the spaces between them occupied by a filamentous fungus and rather large prismatic crystals.

An idea may be formed of the size of some of the crystals by the power under which the drawing, fig. 8, was made—viz. 50 diameters. On removing a portion of the filamentous mass for examination with higher powers, I found the filaments intimately mixed up with the crystals; the former were on an average 1-500th of an inch in diameter, whilst some of the latter were 1-8th of an inch square; most of the filaments had numerous globular bodies, about 1-800th of an inch, adherent to them, but many were scattered about irregularly; these I concluded might be the spores—they are shown in fig. 8. It now becomes a question whether this fungus is of the same nature as that termed *Merulius lachrymans*, which is said to be the cause of dry-rot. I have tried in vain to get any fungus resembling it in specimens of dry-rot taken from wood employed in building, and I never recollect seeing anything at all like it in the interior of any specimen of wood, either living or dead. The crystals are very peculiar, they may be readily seen by the naked eye studding the surface of some of the sections; some of them are so intimately mixed up with the filaments of the fungus that the crystalline matter appears to have been deposited upon them. A large crystal is shown in fig. 9, having fungi in its interior; one of these is represented in fig. 10.

It would appear, therefore, that the fungi were in a great measure auxiliary to the fall of the limb in question, if not the entire cause of it, the effect of the growth of the filaments being the separation of the woody fibres and a destruction of the channels through which the sap flowed; this last, being diverted from its usual course, no doubt lost a great portion of its watery part by absorption, and the solid matter held in solution then began to crystallize. The parts most thickly coated with the fungi are free from crystals; in fact, the fungi are so numerous as to form a perfect coating over the wood, some of the filaments being still white, but the majority of a light-brown colour. In those pieces of wood in which a cavity or cavities have been formed by the separation of the woody fibres, the crystals are most numerous. They are generally of a tabular form, and so transparent that the filaments of the fungi over which they have formed may be readily seen within them. I have not yet been able to ascertain the exact chemical composition of the crystals, but they are soluble in dilute acids, and probably consist of some vegetable acid, with lime as a base. The occurrence of fungi, visible to the naked eye, within a living oak tree, is a fact which few, if any, persons have yet described; but the fungus of the dry-rot in wood which has been exposed to circumstances favourable to its development is far from being uncommon. The fungus now in question would appear to differ from the *Merulius lachrymans* in growing in the interior of a living tree, whilst that is stated in books to commence growth in the sap-wood on the exterior. It would be interesting to ascertain whether a similar fungus exists in other parts of the same tree; and I shall endeavour to enlist the owner of it in the cause of science, in order that, when the time comes for this ancient inhabitant of the forest to be cut down, some competent person may be allowed to examine it. It may happen that fungi are more frequently present in wood than has been imagined, and when such timber is made a part of a ship or building it may be the first to show symptoms of decay.

The ravages of fungi are very remarkable. At one of the early meetings of this Society we had two papers on the decay of fruit, in which Dr. Hassall showed that the rottenness in bruised or over-ripe apples, pears, &c. depended upon the growth of fungi. We have now another instance of it in the oak, and I think that the further investigation of this subject would be well worthy the attention of microscopists. It was a fortunate thing, perhaps, that a microscopical observer happened to be present when the limb of the tree in question fell, for, as it was beginning to rain heavily at the time, all trace of the filaments would either soon have been washed away, or they would have become so much injured as not to have attracted notice, and thus the observations contained in this paper (valueless as they may at first sight appear) would not have been recorded.

REPORT

OF

THE THIRTEENTH ANNUAL MEETING

OF THE

MICROSCOPICAL SOCIETY.

The Microscopical Society of London held their Thirteenth Annual Meeting, February 11th, 1853,—**George Jackson**, Esq., President, in the Chair,—when the following Reports were read:—

1. *Report of Council.*—According to annual custom the Council have to make the following Report on the state and progress of the Society during the past year.

The number of members reported at the last anniversary was 183, including six associates and honorary members. Since that time there have been elected thirty: making the number 213. This number must, however, be reduced, by three deceased and nine withdrawn, giving a total of 201 as the present number of members, and showing an increase of nineteen upon the number reported at the last anniversary.

The Council have also to report that a proposal having been made by the Editors of a new Microscopical Journal to publish the Transactions of the Society in that work, the Council have acceded to that proposal; and the first two parts of the 'Quarterly Microscopical Journal' have been published, containing the Transactions. These, if required, may be obtained separately by members of the Society without charge; and the whole publication may be had by the payment of 4*s.* per annum extra.

Several new works have been added to the Library, as well as many new objects to the Cabinet; and there are also in the possession of the Society various drawings and diagrams, relating principally to the papers read before the Society, together with copies of the several parts of the Transactions.

2. *Report of Auditors.*—The receipts and payments have been as follows:—

REPORT OF AUDITORS

From February 12th, 1852, to February 11th, 1853.

RECEIPTS.		£.	s.	d.	£.	s.	d.
Balance from previous year					1	0	8
For Entrance of Members,	1852	18	18	0			
,,	1853	6	6	0			
Annual Payments	1849	1	1	0			
,,	1850	1	1	0			
,,	1851	6	6	0			
,,	1852	73	10	0			
,,	1853	64	1	0			
Transactions sold		11	18	8			
Half year's Dividend on 210*l.* 5*s.* 11*d.* Consols		6	2	6			
					189	4	2
					£190	4	10

PAYMENTS.	£.	s.	d.
Rent of Room one Year	20	0	0
Salary of Curator	7	10	0
,, Assistant Secretary	21	0	0
Attendance at Meetings, Gas, Oil, Firing, &c.	8	9	9
Refreshments, &c. at Soirée	16	8	9
Stationery, Postage, Carriage, &c.	10	4	11
Printing Transactions and Reports, Lithography, Binding, &c.	65	11	4
Commission to Collector	8	12	0
	£157	16	9
Balance at Banker's	32	8	1
	£190	4	10

February 11*th*, 1853.—I have examined the above Accounts, and compared them with the Treasurer's book, and found them correct.

HENRY DEANE.

The other Auditor was not able to attend.

The President delivered the following Address:—

Gentlemen,—It has been customary on the recurrence of the anniversary of this Society for the President to make some observations, in addition to the reports of the Auditors and Council, on the progress made during the past year.

In compliance with that custom I have first to congratulate you on the accession to our ranks of no less than thirty new members; a greater number, I believe, than have been elected in any one year since the formation of the Society. That our members, both new and old, take an interest in our proceedings, is evinced by the increased attendance at our ordinary meetings; while the subjects brought forward, and the discussions which have taken place on them, sufficiently prove that a large proportion of us are working microscopists.

By the Auditors' Report at the last anniversary we were informed that the funds in the Treasurer's hands, which at the previous audit amounted to 85*l.*, had become reduced to the small sum of one pound and eight pence. At the same time the publication of our Transactions was considerably in arrear; and to add to our difficulties, the Horticultural Society, whose rooms we have hitherto occupied at a rent proposed by themselves, gave us to understand that this rent would be increased by ten pounds a year. The ground assigned for the increase was the large amount of accommodation afforded to us; and inasmuch as the occupation of the council-room every Wednesday by our curator was not contemplated when the rent was originally fixed, there was some show of justice in the demand. It was found also that very few of our members availed themselves of the opportunity afforded them of coming here in the daytime to use the microscopes. The Council, therefore, judged it proper, in accordance with the economy which the state of our funds so peremptorily obliged us to exercise, to discontinue the Wednesday attendance of the curator, by which they hoped not merely to save his salary, but also to remove the ground assigned for the proposed increase of our rent.

In this latter expectation they have been disappointed. The Horticultural Society persist in their determination; and it has therefore been resolved to remove our meetings to No. 5, Cavendish Square, where the Chemical Society will afford us the use of very eligible rooms, together with light and fire, for the rent which we have hitherto paid without these accommodations.

By the Auditor's Report, just now read, you will perceive that, although we have brought up our arrears of publication to the month of June last, and have paid all our debts, we have now a balance in hand of 32*l.*, which the economical measures adopted by the Council will, I hope, increase during the next year.

In order that the members may not be deprived of the opportunity of using the microscopes, examining the objects in our cabinet, and consulting and exchanging books, the Council has engaged a curator to attend at six o'clock on the evenings of our ordinary meetings, which, it is hoped, will be found more convenient than the day attendance that has been discontinued.

The necessity for the prompt publication of our Transactions has been adverted to by more than one of my predecessors, and must be sufficiently obvious to all of us; for when a man has observed a new fact, or suggested an improvement in the mode of observing, and has determined to bring the matter before the public, he is seldom contented with the notice which the mere reading of his paper may attract, but is anxious to see it disseminated in print, so that his claim, either of discovery or invention, may rest on a firm basis. Unless, therefore, we can offer these advantages, we must expect that many interesting papers which might otherwise have come to us will be taken elsewhere, and be submitted to the public through some more expeditious channel.

In accordance with these views, the Council has made an arrangement with two of our members, who have commenced a Quarterly Journal of Microscopical Science, for the regular printing of our Transactions in that periodical; so that authors will not only see their papers promptly published, but will also enjoy the benefit of the large circulation which the Journal has obtained. Our members, also, in addition to a copy of the Transactions, will obtain all the other matter which the Journal contains for one shilling per number.

On the value of this matter, as two numbers have been already published, it is needless for me to expatiate at any length. Besides interesting original communications from observers in our own country, by means of translations and extracts from foreign journals and reviews of foreign works it affords to the mere English reader the knowledge of what is being done by microscopists in all parts of the world; and by thus giving a starting point to his inquiries, prevents his wasting his time and energy in re-discovering what has been already observed.

The publication in full of our Transactions up to the end of June last, and the abstracts in the Journal of the papers read before us in October, November, and December, render it unnecessary for me to go so deeply into the contents of these communications as has been usual at former anniversaries.

Mr. Shadbolt's paper, containing a variety of useful practical information on the habitats and mode of collection of a number of beautiful microscopical objects, was listened to with much attention, and elicited many remarks and inquiries, and, had it not been already published in the Journal, would have demanded from me a more extended notice.

The paper of Mr. Simonds records an interesting pathological fact. As a medical man, I cannot help regretting that pathology is a subject on which we have very few communications; for I feel assured that the investigation of the products of disease is one of the most *immediately* useful purposes to which the microscope can be applied; and I believe that such communications would be well received, not merely by those of my own profession, but by the members generally.

The paper of Mr. Mummery on the development of Tubularia indivisa, and those of Mr. Busk and Mr. Williamson on Volvox globator, contain a vast amount of well-illustrated microscopical observations.

The same praise is due to Mr. Busk's paper on Starch, which also teaches us the useful lesson, not to be satisfied with examining things in their natural state, but, by applying reagents under the microscope, to combine chemical research with microscopical observation.

The subject of Microscopical Photography, on which Mr. Delves has favoured us with a communication, accompanied by some beautiful specimens, is one of great interest. That it will attain a high degree of perfection no one who knows the persons engaged in its cultivation can reasonably doubt. There is, however, a difficulty in its application, which, I fear, will materially limit its use.

Those who have been in the habit of using the microscope since the first introduction of achromatic lenses must have noticed that in proportion as the object-glasses have increased in aperture and improved in definition they have lost the power of penetrating to any depth; and this has now been carried to such an extent that when we examine with a high power any but the thinnest objects lying in an almost mathematical plane, we can only do so effectually with the finger on the fine adjustment to regulate the focus for the particular point on which the eye is fixed.

This precision of focus, which is a necessary consequence of precision of definition, must have the effect of confining photography (except with low powers) to the representation of the class of objects above described; or of only allowing us the alternative of having portions of them well delineated while the rest is indistinct. Other difficulties attending Microscopical Photography have been pointed out in Mr. Hodgson's paper, on which it is not necessary for me to dilate.

In spite of these obstacles, I venture to prophesy that this beautiful art will flourish; for its want of universal applicability need not prevent its use in the numerous cases to which it is appropriate.

The paper of the Rev. William Smith on the Stellate Bodies occurring in the cells of fresh-water Algæ gives some further details of these plants, which may hereafter assist us in forming a more correct theory of their physiology.

Our Secretary, to whom we have formerly been so much indebted for valuable contributions, has recently read a very interesting account of some observations he has made on the presence of a fungus, and of masses of crystalline matter, in the interior of a living oak tree; a circumstance which does not appear to have been previously noticed, and which hardly admits of a satisfactory explanation in the present state of our knowledge. It is not, however, less worthy of record on that account; for all sound theory must be based upon carefully-observed facts; and the first fact of a kind is at least as valuable as those which may hereafter follow it.

The very large demand for first-class microscopes, which has increased rather than diminished during the past year, has stimulated the makers to use every exertion to extend to the utmost the apertures of their object-glasses. Messrs. Smith and Beck have produced a 4-10th inch of upwards of 90°, chiefly valuable for the examination of opaque objects. Mr. Ross has lately made some objectives of 1-8th inch focal length, and 155° of aperture, which, by permitting very oblique illumination, bring out the markings on the most difficult test objects in a highly satisfactory manner. Mr. Wenham, in following up his experiments to ascertain the limits of useful aperture, has constructed a glass of 170°, and 1-12th inch focus; but is still of opinion that nothing is gained beyond 150°. From a very brief examination of his object-glasses, I am inclined to differ with him, and to think that for the purpose of *merely discovering the existence* of very close lines or dots the aperture cannot be too great. For the *useful* application of the microscope to minute anatomy and physiology a much smaller aperture will suffice, which, from not requiring such careful adjustment, and such close proximity to the object, is far more convenient in use.

When we consider that the real aperture of an object-glass is the chord of the angle at which light is admitted, and that the chord of 170° is more than ·996 of the diameter of a circle, we may be certain that if the extreme limit has not already been reached, its further extension will scarcely be appreciable. To correct the aberration of these glasses as far as possible, and to bring them to the neatness of definition that has been attained in those of more moderate aperture, must now be the aim of our scientific opticians.

A very useful addition to the mechanical arrangements of the microscope has been contrived by Mr. Brooke. In former days, when our objectives were single lenses, it was usual to set four or six of them in a wheel, by turning which the power could be changed in a moment. Our present object-glasses, consisting generally of three achromatic combinations, requiring to be set in tubes of some length and thickness, cannot be compressed into so small a space. Mr. Brooke has, however, effected the same purpose to the extent of two powers. To the nozzle of the microscope an arm is screwed, projecting in front, and carrying a pin on which a bar revolves, to each end of which an object-glass is screwed. Either of these, by rotating the bar, can be brought under the body of the instrument, while the other is carried beyond the stage so as to be quite out of the way. Object-glasses of one inch and one-quarter inch mounted in this way are found to be very convenient when pursuing microscopical researches; the one to take a general view, and the other a particular one, of the object under inspection.

Mr. Brooke also exhibited a neat little contrivance for converting a pocket eye-glass into a table microscope. Two straight square pieces of brass are halved into each other, and the pillar on which the eye-glass slides screws into the intersection, the straight pieces forming the foot. The whole makes a useful stand, and packs into something smaller than an ordinary spectacle-case.

Mr. Ross has constructed a very comprehensive microscope-stand, furnished with right-lined and circular motions, not merely to the stage but to what may be called the *sub-stage*, or that part which carries the different illuminators for transparent objects. All these motions being effected either by pinions or screws, the various adjustments are made with great comfort to the observer. The instrument is heavy, and the quantity of excellent work in it necessarily renders it somewhat costly.

Messrs. Smith and Beck have adopted an improved method of attaching the object-glass to the body for the purpose of preventing the excentricity which is frequently caused by the imperfection of the screw. They have also carried the same principle into the construction of the eye-piece by attaching the cells to the tubes by cylindrical fittings.

Here, Gentlemen, I would willingly conclude; but I have still the melancholy duty remaining of recording the death of three of our members, a duty from which my predecessor was last year happily exempted.

Of Mr. Edward Stokes I had no personal knowledge; but I have been informed that he was a zealous cultivator of science.

Mr. Dalrymple and Dr. Mantell have both left names which will not speedily be forgotten, and which merit a much more extended notice than it is in my power to give.

John Dalrymple was the eldest son of William Dalrymple, a highly distinguished surgeon at Norwich, under whom he received the early part of his professional education. He afterwards studied at the University of Edinburgh, and in 1827 became a member of the Royal College of Surgeons in London, and settled in the city. In 1832 he was elected Assistant-Surgeon to the Royal Ophthalmic Hospital, and Surgeon in 1843. In 1847 he retired from that office on account of ill health, and was appointed Consulting Surgeon. In 1851 the Fellows of the Royal College of Surgeons elected him a Councillor. He published a work on the Anatomy of the Eye in 1834; and a splendid one on the Pathology of that organ he only just lived to complete. In fact, he revised the last number but a few days before his death. His style is clear and concise; and the soundness and precision of his views, and the accuracy of his delineations, are universally acknowledged by the profession. In 1839 he removed from the city to the west end of London, where his practice increased, and latterly had become greater than was compatible with the state of his health. In addition to his own peculiar department of surgery, in which he had attained the highest eminence and the full confidence of the profession, he successfully prosecuted the delicate and interesting science of microscopical anatomy, both human and comparative. He was an original member of this Society, and one of our first council; and he contributed a valuable paper "On the Arrangement of the Capillary Vessels of the Allantoid and Vitelline Membranes in the incubated Egg" to the first volume of our Transactions. Until illness obliged him to spend his evenings at home, he was a frequent attendant at our meetings; and his remarks, when he took a part in our discussions, were characterised not less by clearness and precision than by the modest and gentlemanly tone in which they were delivered.

Soon after the death of Dr. Gideon Mantell a brief memoir of him appeared in the Athenæum, from which I shall extract a few particulars. Although a member of the medical profession, he was not a graduate in medicine, but derived his title from the degree of LL.D. conferred by a foreign university. He commenced his career as a general practitioner at Lewes; removed to Brighton in 1835, and to London in 1839, residing first at Clapham, and afterwards in Chester-square. He was naturally an enthusiast, and, gifted with quick observation, he would have distinguished himself in almost any branch of science. The accident of his position made him a geologist; for little was then known of the Wealden formation, or of the fossils which it contained. Seldom has an observer had a richer field for the exercise of his powers, and seldom has an opportunity been better seized. In the course of a few years he collected together a museum of specimens from the Wealden and the chalk which now forms a portion of the British Museum, the trustees of that institution having purchased it for 5000*l.* His first paper, published in 1813, was on the organic remains discovered in the environs of Lewes; and from that period almost to the time of his death his literary labours were unceasing; for on the subjects of Zoology and Botany no less than sixty-seven papers and works have been enumerated. When it is remembered that during all this time he was pursuing the active practice of his profession, contributing papers to the medical journals, and occasionally writing on other subjects, we may form some idea of his indefatigable industry.

Dr. Mantell had also the satisfaction of making known the important discovery, by his son, of the remains of the gigantic birds of New Zealand, of which he possessed many very fine specimens, and on which he wrote several papers.

Of his talents as a popular lecturer I can speak from my own observation. Possessed of a rapid and even flow of appropriate language, sometimes rising into eloquence, and being enthusiastically fond of his subject, he managed to inoculate his audience with the same enthusiasm, and therefore had no difficulty in keeping up their attention even when he trespassed considerably beyond the accustomed hour. He was an occasional but not frequent attendant at our meetings.

Permit me, Gentlemen, in conclusion to thank you for the kind indulgence with which you have received my very imperfect endeavours to fulfil the duties of your President. Of their imperfection no one can be more sensible than myself; but at the same time no one can more sincerely desire the continued prosperity of the Society, or *strive* more to promote it.

Resolved unanimously—That the Reports of the Council and Auditors be received; and that they and the President's Address be printed in the Transactions of the Society.

The law relating to the election of officers was then read; and the Society proceeded to ballot for the officers and four new members of council for the year ensuing.

The ballot having been taken, the following were declared elected:—

Officers.

President	GEORGE JACKSON, Esq.
Treasurer	N. B. WARD, Esq.
Secretary	JOHN QUEKETT, Esq.
Assistant Secretary	Mr. JOHN WILLIAMS.

New Members of Council.

W. GILLETT, Esq.
JOHN LEE, Esq., LL.D.
ROBERT WARINGTON, Esq.
F. H. WENHAM, Esq.

In the room of

M. S. LEGG, Esq.
M. MARSHALL, Esq.
ALFRED ROSLING, Esq.
J. B. SIMONDS, Esq.

Resolved unanimously—That the thanks of the meeting be given to the President, Treasurer, Secretary, and Members of Council, for their services on behalf of the Society during the past year.

On the Minute Structure of a Species of FAUJASINA. By Professor W. C. WILLIAMSON. Communicated by Matthew Marshall, Esq. (Read June 22, 1851.)

IN the last memoir on the Foraminifera which I laid before the London Microscopical Society, I pointed out the existence of a curious system of tubes and canals, penetrating the parietes and septa of several species of Foraminiferous shells. In *Polystomella crispa* these chiefly presented themselves in the form of large canals passing through the calcareous umbilical regions. In some species of *Nonionina* and *Amphistegina* they existed as a dense network of minute canals, having their external orifices at the peripheral margins of the discoid shells. In the latter examples the canals were of small diameter, and their use in the economy of the living animal very dubious.

On making a number of sections of a species of *Faujasina* (D'Orb.) from Manilla I discovered the existence of a much larger and more interesting arrangement of tubes than any that I had previously seen. This shell is constructed on the inequilateral plan of the common *Truncatulina tuberculata.* Its inferior surface is flat, the corresponding extremities of the segments being arranged on a nearly uniform plane. As successive convolutions have been added to the antecedent ones, they have assumed the arrangement of a series of hollow cones placed over one another, the additions to the length of each new segment being confined to its upper extremity. Hence, whilst inferiorly all the convolutions are visible, on the upper surface we only see the outermost one presenting the aspect of a truncated cone.

Fig. 1, Pl. X., is an enlarged representation of the lateral appearance of the shell, viewed as an opaque object. Whilst the vertical septal lines (1 *d*) are translucent, the intervening parietes of the segments (1 *g*), in which the minute foramina exist, is of an opaque gray colour. The inferior peripheral margin (1 *f*), and its continuation at the flat inferior surface, constituting the spiral septum (fig. 2 *e*) separating the convolutions, exhibit the same translucent aspect; as does also the truncated apex of the cone (1 *d'*), towards which all the vertical septa converge. In nearly all the Foraminifera a translucent line appears to mark the existence of a subjacent septum. The segments, which do not extend to the summit of the shell, communicate with one another by one very large oral aperture (1 *e*).

Along each of the vertical septal lines (1 *d*) there exists an irregular double row of very distinct pits or depressions (fig. 6 *f*). Similar pits are seen inferiorly in the radiating septa which divide the different segments of each convolution (fig. 2 *b* and *d*), but they do not occur in the peripheral margin (1 *f* and 6 *e*), or in the spiral septum (fig. 2 *e*). At the upper extremity of the shell similar, but larger, pits are seen both on the flat truncated surface (1 *d a′*) and on the sides intervening between it and the upper portions of the segments (6 *b*). On making a series of sections of the shell we learn that these pits are the external orifices of a curious system of intra-septal canals and spaces, ramifying in its interior.

Fig. 2 represents a thin superficial section of the inferior flat surface, viewed as a transparent object. Thus examined, the conditions are reversed. The foramina in the parietes of the hollow segments tend to intercept the light and look dark, whilst the solid calcareous septa are translucent and transmit it freely. This section was made a little below the peripheral margin and parallel with the points *a*, *a* in fig. 1.

The walls of the segments (2 *a*) exhibit the ordinary foraminated aspect, and the segments themselves are arranged in the usual spiral manner. The spiral contour is lost in the centre of the section, owing to the circumstance that it there becomes very thin, and passes under the central cells which are placed a little above the level of those which surround them. In the radiating septal lines are seen numerous small orifices (2 *b*), which open by means of short canals (fig. 5*h*, *h′*) into the interseptal spaces immediately above them. As already observed, these orifices do not exist in the spiral septum (2 *e*), but here and there even this superficial section exhibits traces of deep-seated canals passing through the septum and uniting the orifices belonging to contiguous convolutions (2 *c*). In this portion of the shell the apertures are usually in single rows; but towards the exterior of the outer segments we sometimes see them arranged in pairs (2 *d*). It is of course the *external* surface of the base of the shell that is represented in the drawing.

On making a second section parallel to the last, but a little above the peripheral margin, in the plane of the points 1 *b*, *b*, we have the appearance presented by fig. 3. The drawing represents this section as seen when viewed in the opposite direction to the last, viz. looking at its upper or inner surface, and towards the base of the shell—some of the foraminated parietes of which are still preserved.

We now perceive that there exists a number of large branching intra-septal tubes and passages, which commence at the innermost segments and proceed in a radiating manner towards the periphery. As each of these tubes emerges from the septum separating two contiguous segments, and reaches the spiral one intervening between two convolutions, it exhibits a marked tendency to divide into two branches (fig. 3 *a*, *b*), one of which is usually in a plane a little above the other. On tracing back these tubes as they proceed from the outermost to the inner convolutions, we perceive that the bifurcations, which at one time marked the outer extremities of each series, serve two purposes: they are designed, primarily, to multiply the number of the external orifices; but in addition to this, they subsequently facilitate the establishment of a free communication between the internal intra-septal spaces and those of the newer convolutions, in which the septa are much more numerous; but though a lateral divergent communication is thus maintained, I have only seen one instance in which a *direct* lateral communication was established between two transverse septa of the same convolution, parallel with the spiral septum. The exception is seen at fig. 3 *c*. In this respect the species under consideration differs materially from the forms described in my preceding memoirs. The small circular apertures which appear along the course of these tubes, mark the points where the section has traversed the orifices of the canals descending to the inferior surface of the shell.

Fig. 4 represents a third section made across the points fig. 1 *c c*. This section has cut through the shell a little above the superior extremities of the cells belonging to the central convolutions; a few of those belonging to the second spiral being seen at 4 *a*. The outermost convolution, on the other hand, has been intersected across its large oral (?) apertures (fig. 1 *e*), revealing the nature of the connection (4 *b*) that exists between contiguous segments. We now see that the portions, which in the section fig. 3 had the appearance of large radiating tubes, are really the lower borders of vertical intra-septal spaces (fig. 4 *c c′*), which also give off true divergent cylindrical canals from their external margins, penetrating the thick parietes of the shell. These spaces extend from the top to the bottom of each septum, and only assume the form of canals when they approach the peripheral shell walls. The connecting branches which unite the spaces of different convolutions (fig. 3 *b*) are also tubular.

The septa of the second convolution in this section exhibit similar intra-septal spaces (4 *d*), which communicate externally, as just described, with those of the outermost convolution, and also open internally into a large and very irregular central cavity (fig. 4 *e* and 5 *g*). The true nature of this cavity will be better understood on referring to fig. 5, which represents a vertical section of this instructive object, passing nearly through its centre. I am not quite certain whether it has actually traversed the primordial cell, but if not, it has certainly crossed the second one (see fig. 3), which is seen at *a*, along with four others, *b*, *c*, *d*, and *e*, in the order of their successive development. Whilst their inferior portions of the segments are nearly on an uniform level, the upper extremites of those belonging to successive convolutions become rapidly elongated, leaving between them a large, irregular, conical space (fig. 5 *g*, *g*), the inverted apex of which rests upon the most central segment (5 *a*) and communicates with the inferior surface by means of the canals fig. 5 *h′*. Similar canals are also seen at 5 *h*, passing upwards into the inter-septal spaces; whilst at 5 *i i′*, corresponding ones proceed inwards through the respective septa of the cells *c* and *d*—in the translucent walls of the latter of which their direction, and the extent of the inter-septal space may be traced.

I have not in any one instance found these spaces, or their divergent canals, communicating with the interiors of the segments, though at the first glance many of them appear to do so, as is the case with the inner margin of the large segment fig. 5 *d*. But from the examination of a considerable number of sections, I am satisfied that where such an appearance exists, it is either the result of an accidental fracture or an optical illusion; and that the only direct communications existing between the two parts of the organism, are through the pseudopodian foramina, many of which open into the tubular portions of these passages (figs. 3 *d* and 4 *f*); but never, as far as I have observed, into the intra-septal spaces.

But the section now under consideration, in common with several of the others just described, presents a new and curious feature. The cavities in the translucent calcareous shell are thickly lined with a dark olive-brown substance, apparently the residuum of the soft animal. This substance not only exists in the interior of all the segments, closing up the oral apertures, as at 5 *f*, but also occupies the intra-septal spaces and their respective canals, as well as the irregular cavity in the umbilical centre of the shell. If this substance is really the desiccated soft animal—and of this we should not have entertained a doubt, had it existed only in the interior of the segments—it is evident that in this species the gelatinous tissue has not only filled the true chambers but has also occupied the intra-septal canals and passages. The specimen from which the section, fig. 4, was prepared, exhibited the same appearance, and traces of it occur in all; hence it appears most probable that this brown substance is really the desiccated soft animal. If this should prove to be a correct conclusion, it is curious that the only medium of communication between the soft tissues inhabiting the spiral segments of the shell and those occupying the intra-septal and central passages, should have been the minute pseudopodian foramina. The structure is so very different in this respect, from anything that has been previously observed, that I am afraid to speak with too much certainty on the subject, though I entertain but little doubt respecting it.

On examining the external contours of young examples of this species, we often find the apex occupied by a deep and irregular depression, surrounded by the projecting upper extremities of the segments constituting the external convolution. This depression, which is really identical with the irregular central cavity (fig. 5 *g*, *g*), subsequently becomes arched over by a calcareous layer (fig. 1 *d*), derived from the upper portions of the newer convolutions. The roof thus formed is perforated by large apertures (fig. 6 *b*), through which a free communication is maintained between the external medium and the enclosed space. The nature of the latter varies considerably. Sometimes it exists in the form of a large irregular cavity, as already described, and at others as an intricate network of large canals. The character of the external orifices also varies. In some examples they are large and patent, as in fig. 6 *b*; in others, numerous smaller tubes, ascending from the subjacent network, converge at some superficial depressions which occupy the position of the larger orifices. Fig. 6 represents a thin superficial section made in the plane of the oblique sides of the conical shell and exhibits three septa (6 *c*), with the large orifices of their intra-septal canals (*b f*), part of the external parietes of four segments (6 *d*), densely perforated with minute pseudopodian foramina, part of the inferior peripheral margin (6 *e*), and a small lateral portion of the dome-like apex of the shell (6 *a*).

The preceding facts are sufficient to show that the subject of this brief memoir presents a very different structure from any of the Foraminifera hitherto described. Whether or not my supposition as to the probable occupation of the intra-septal canals and spaces by the gelatinous soft animal be established, it is obvious that this organism supports the conclusion at which I arrived in a preceding memoir, viz. that the soft animal had the power of extending itself externally far beyond the limits of any individual segment, and would thus be able to secrete calcareous matter in other situations than the mere parietes of its own segment. It is only in this way that we can explain the production of the dome-like covering which encloses the central umbilical cavities and their ramifying canals. But if it should be ultimately proved that the soft tissues have occupied all these irregular cavities, we shall then have a form of organization which, from its great variability of contour, will approach much more closely to the calcareous sponges than any hitherto described.

I am well aware that, to many, these dry details will appear unnecessarily and tediously minute; but it must be remembered that, until we are accurately familiar with all the leading types of structure existing in this interesting group of organisms, we cannot be in a condition to arrive at final conclusions respecting their nature and zoological position.

Manchester, May 21st, 1851.

Notice of a Diatomaceous Earth found in the Isle of Mull. By WILLIAM GREGORY, M.D., F.R.S.E., Professor of Chemistry in the University of Edinburgh. Communicated by Professor JOHN E. QUEKETT. (Read March 23rd, 1853.)

THIS earth was discovered, about two years ago, by the Duke of Argyll, who gave a short account of its geological position to the Royal Society of Edinburgh. It constitutes a bed, resembling marl in appearance, lying in a rough piece of ground, at Knock, near Aros, between Loch Baa, a fresh-water lake, 3 miles long and 1 mile broad, and the sea. The lake is about 30 feet, the land about 40 feet, above the sea-level, and the lake is surrounded with high mountains on all sides except the west, where its waters flow towards the sea, passing through the rough district, boggy in parts, above mentioned, which is about a mile broad. The marl-bed, as it is called on the spot, lies within 50 yards of the lateral granite rock, and half-way from the lake to the sea. The surface of the land between the lake and the sea is very uneven, covered with large stones, gravel, and sand. At one part there is a hollow, which in winter used to become a small loch, in summer only a stagnant pool, and in draining this the bed of marl was discovered. It was filled in summer by a small stream unconnected with the lake. The bed rests on the gravel, which again rests on the granite of which the whole district is formed. As there is no formation of an epoch between those of the granite and of the gravel, we cannot, from its position, ascertain precisely the geological period at which the bed was deposited. The Duke of Argyll regards the gravel as belonging to the Diluvium, and the Infusorial deposit as comparatively of very recent origin. But there is reason to think, from the character of the species, that the deposit may belong to a more remote epoch. Ehrenberg, to whom I sent a portion of it, writes to me, that he thinks it probably connected with the Tertiary, or at all events, with the Quaternary period, but he had only been able to make a partial examination of it at the time he wrote.

This deposit must not be confounded with the Leaf-bed, also discovered in Mull by the Duke of Argyll; for that bed, which also contains a large number of Diatomaceous remains, occurs at a place 20 miles from the deposit now under consideration, and is found between two beds of volcanic trap, showing that the Dicotyledonous trees—remains of which abound in it—must have lived before the eruption which gave rise to the upper trap bed, whatever may have been the period of that eruption.

To return to the Infusorial deposit. The Duke of Argyll thinks it possible that the waters of Lock Baa, which now pass to the sea at a distance from the deposit, may, at one period, have flowed through the hollow where the deposit is found. Mr. Campbell Paterson, a gentleman residing on the spot, thinks that the sea at one time communicated with Loch Baa, and that the present barrier is the result of some geological change or convulsion. The gravel and sand, he says, exactly resemble those now forming in the neighbouring sea; and although he has not observed any marine shells in the gravel, he thinks that the rocks at a higher level bear marks of the action of the sea. These are points on which I cannot speak without a personal knowledge of the locality, but the deposit appears to contain only fresh-water organisms.

The Duke of Argyll kindly gave me a small portion of the earth first discovered, which happened to be very pure, and which he stated to contain *Naviculaceæ.* On examining it, I was struck with the variety of forms, and resolved to study it more closely; this I have only been able recently to do, and I think the results may prove not uninteresting to the Microscopical Society.

The Mull earth is, in the purest specimens, when dry, almost white, and much resembles chalk, being light, friable, and adhering to the fingers. But more commonly it has a pale fawn colour, and it is frequently strongly tinged with iron. The lightest and whitest specimens contain hardly anything besides siliceous organic remains, for the most part entire, but with some fragments. Other portions, which are denser, contain also many fragments of quartz of various sizes, and vast numbers of comminuted fragments of loricæ. In the densest and worst, the quartz or sand and the fragments entirely predominate, and these can hardly be cleaned. The specimens of middling quality, as well as the inferior ones which I at present possess, contain a great many minute fragments of loricæ, often exceeding half or three-fourths of the mass. These fragments form an excellent polishing powder, which may be had of various degrees of fineness. I find it best, except in the case of the very purest specimens, first to ignite the earth over the spirit-lamp in a platinum capsule, till the black colour first caused by the action of the heat on the organic matter present is burned off, and the earth is again nearly white. I then digest it for some hours in strong nitromuriatic acid, which removes the iron, and, after washing away the acid, press the lumps in water gently with the finger till the whole is diffused in the water. It is then elutriated as usual, to separate on the one hand the coarse sand, if any be present, and, on the other, the comminuted fragments. The slides now offered to the Society were prepared in this way from earth of but middling quality, my supply of the purest having been very small and long ago exhausted; while the deposit being at present, and for months past, flooded, it is impossible to procure a fresh supply of the purest earth.

In endeavouring to identify the species present in this earth, I found the greatest difficulty from the want of any work containing figures of all the known species. The only figures I could procure were those of Ehrenberg's Atlas, 1838, and those of the last edition of 'Pritchard's Infusoria.' The former, of course, does not contain the very numerous species added to the list since 1838, and the latter has seldom more than one or two species in each genus. I had also Kützing's 'Species Algarum,' without any figures. But I was able, after studying a good many slides of excellent quality, to distinguish somewhere about 65 forms, although I could not with any confidence name above one half of the number. Under these circumstances, I ventured to apply to the Rev. W. Smith, to whom I was fortunately able to send an excellent specimen of the earth. That distinguished naturalist had the very great kindness, in spite of his absorbing occupations, to examine the earth, and to send me the following list of species which he has detected in the specimens sent. The names are those adopted in his forthcoming synopsis:—

Pinnularia major
,, acuminata
,, oblonga
,, viridis
,, divergens
,, acuta
,, radiosa
,, mesolepta
,, interrupta
,, Tabellaria
,, gibba

Pinnularia gracilis
,, lata
,, alpina
Navicula serians
,, rhomboides
,, ovalis
,, dicephala
,, firma
,, angustata
Gomphonema acuminatum
,, cruciatum

Gomphonema Vibrio
,, capitulatum
Amphora ovalis
Stauroneis Phœnicenteron
,, gracilis
,, linearis
,, anceps
Cymatopleura elliptica
,, apiculata
Cocconeis Thwaitesii
,, Placentula
Surirella Brightwellii
,, biseriata
Cymbella Helvetica
,, maculata
,, sativa
,, affinis
,, cuspidata
Himantidium gracile, Kütz.
,, bidens, W. Sm.
,, pectinale, Kütz.
,, arcus, Kütz.
,, major, W. Sm.
,, undulatum, Ralfs.
Tabellaria frustrata, Kütz.
,, ventricosa, Kütz.
Epithemia turgida
,, gibba
Eunotia gracilis
,, retrorsum
,, Diadema
Synedra capitata
,, biceps
Fragillaria capucina, Kütz.
Orthoseira viridis, W. Sm.
,, ouchalcea, W. Sm.

It will be perceived that Mr. Smith has found, in the specimens sent to him, 59 species of fresh-water Diatomaceæ. As I had made sketches of all those forms which I could not name, I was easily able to identify Mr. Smith's species. I have stated that I had distinguished about 65 forms. I believe that some of these were side-views of species unknown to me at the time, and others, in all probability, accidental varieties. But I also think it probable that there may be a few species in the deposit which do not occur in the portion seen by Mr. Smith. At least, I am quite certain that that portion differs remarkably in some points from that which I had under examination at the same time. For example, in Mr. Smith's specimen, of which he kindly sent me two slides as I had not tested it myself, I find that there are numerous and fine loricæ of *Epithemia turgida*—a species which I had indeed observed in mine, but which I had found remarkably scarce. I have reason to think that hardly any two specimens will be found exactly to agree, and it is quite natural that different parts of the deposit should differ in the prevailing forms. Among the forms which I thought I had observed, but which Mr. Smith did not meet with, are *Melosiera* distans, and possibly *M. nummuloides; Eunotia Triodon*, and *E. Pentodon;* possibly E. fabra, and one or two more. But most of these, if they do occur, are very scarce; and therefore I do not venture to add any names to Mr. Smith's list until I shall be confirmed by him or by some other experienced authority. There are several other forms, also doubtful, which I thought I had seen, but I need not name them.

The Mull earth is characterised by several peculiarities. First, by the abundance of very fine specimens of the Naviculaceæ, especially of the genera *Pinnularia* (14 species), *Navicula* (6 species), and *Stauroneis* (4 species). There are many splendid individuals of *Pinnularia major* (some 1-50th of an inch in length), oblonga, virides, divergens, and others; and a few, but these very fine ones, of *P. lata*, and of the rare and beautiful *P. alpina*. *Navicula rhomboides* and *N. serians* are particularly frequent and fine, as is also *Stauroneis Phœnicenteron*. 2ndly. It is characterized by the abundance of *Cymbellæ* of which there are 5 species. 3rdly. There is a remarkable development of the *Eunotiæ*, as *Eunotia Tetraodon*, *E. Diadema*, *Himantidium Arcus*, *H. bidens*, and the 4 other *Himantidia* and *Epithemia turgida*. 4thly. There is a great abundance of *Tabellaria fenestrata* in every stage of development, some specimens being 10 or 12 times as long as others, but not broader, and of *T. ventricosa* which, however, occurs almost always short. 5thly. There is a remarkable abundance of fine specimens of *Gomphonema coronatum*, and fine individuals of *G. acuminatum* also occur. The genera *Amphora*, *Cymatopleura*, *Cocconeis*, *Surirella*, and *Nitzschia* occur less abundantly, and in some cases are very scarce. *Fragilaria capucina*, Kütz., *Orthoseira viridis*, W. Sm., and *O. ouchalcea*, W. Sm., are abundant, as is *Synedra biceps*. I have observed the variety β *recta*, Kütz., of this species.

Besides the 59 species named by Mr. Smith (and I would again remind the Society that the names in the above list are those of Mr. Smith's daily expected Synopsis), there is one form, to which I directed his attention, and which he cannot with certainty refer to any known genus. This form is abundant in all specimens of the earth, and is therefore an additional characteristic of it. It varies from 1-600th to 1-470th of an inch in length, and has usually the form of a plano convex lens, with two notches near the ends of the plane or very slightly concave side. It is broadest in the middle, and has sharp apices (fig. 1). At other times the apices are less sharp and the ends broader (fig. 2). It is finely cross striated, and Mr. Smith has ascertained the number of striæ to be 44 in 1-1000th. It requires a very good glass to make out the striæ, and it is possible that this form, from its abundance in the Mull earth, may be found available as a test object. For a long time I could not make out the striæ (although I felt sure of their existence from the resemblance or aspect to other forms known to be striated) with a glass which had sufficed for all the other forms. But with a first-rate object glass, and good management, the striæ may be shown and counted. It is possible that this form may be an immature one, but to what are we to refer it? It differs from *Himantidium Arcus* and *Eunotia gracilis* in the number of striæ, and Mr. Smith thinks it must stand near *Eunotia Arcus*, Kütz.= *Navicula Arcus*, Ehr. It is not, however, that species, nor is Mr. Smith sure that it is of that genus. He is to examine it more fully, and the matter is therefore in good hands. I may add, that while it has a general resemblance to small specimens of *Himantidium Arcus*, or of other allied species, it does not commonly occur where these are abundant. I have looked at a number of Diatomaceous earths, in many of which there were all the common species of *Eunotia* and *Himantidium*, but have only seen this form in one, namely, in a slide prepared by Mr. Topping, and labelled " from the banks of the Spey." This slide has many things in common with the Mull earth. Any of the slides sent with this paper will exhibit numerous examples of this form.

I have further to add, that an average specimen of the Mull earth, on being analysed, was found, after being dried at 212°, to be composed of—

Silica - - - - - - -	70·75
Protoxide of iron, containing traces of phosphoric acid and manganese - - - -	15·04
Organic matter - - - - - -	12·36
Loss, chiefly water - - - -	1·85
	100·00

The iron is here stated as protoxide, but if calculated as peroxide, would amount to 16·69 per cent. Some of it certainly is in the latter form from the action of the air, and the brown colour, and this diminishes the loss, but I have stated it as protoxide, because I believe it to be in that state before the air has access to it. The presence of phosphoric acid, which was easily detected in the oxide of iron, by the use of molybdata of ammonia, is interesting. It is most probably derived from the organic matter of the Diatomaceæ, but I am not aware that its presence has been yet observed in any infusorial earth. I have not determined the proportion of phosphoric acid, which, although small, is appreciable. The earth contains neither lime nor magnesia.

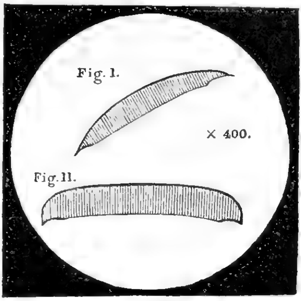
It is probable that this earth may be useful as a manure from the finely divided silica, the organic matter, and the phosphoric acid it contains. Professor Bailey ascribes the fertility of certain districts in America to the abundance of infusorial remains on the soil, so that the experiment is worth trying.

I find I have omitted to notice that, besides the Diatomaceous organisms, the Mull earth contains abundance of the long spicules, and also of the gemmules of *Spongilla fluviatilis* and *S. lacustris*, also a considerable number of siliceous forms, apparently *Phytolitharia*, more particularly *Lithostylidium clepsammedium*, and similar forms. There are also some silicified forms much resembling certain deposits in the cuticle of Gramineæ, &c., besides occasionally silicified pollen grains, belonging both to grasses, and as I believe to Coniferæ. I have also seen some fragments of woody fibre and cells, probably silicified; but I have not the means of determining with any accuracy these various organisms. Probably many members of the Society will be able easily to do this. I think I have seen some forms which resembled very much the Desmidiaceæ, such as *Euastrum*, *Staurastrum*, and *Cosmarium;* but on these points I will not venture to assert anything, although, as Desmidiaceæ occur in flint, and often contains a little silica, this occurrence is possible.

In conclusion, even the imperfect examination to which the Mull deposit has been subjected, proves it to be richer in Diatomaceous species, and I think also in genera, than any other known deposit, so far as I am acquainted with them. I have heard that the deposit at Santa Fiora contains 39 species, and that found near Peterhead, and described by Dr. Dickie, contains 40, but I know of no others which equal these two, whereas in the Mull earth we have at least 60 species and 16 genera. This will of course be interesting in reference to the geographical distribution of fossil Diatomaceæ, and I may add that Ehrenberg, who is preparing to publish a great work on this part of the subject, has been very much interested in the Mull earth, as being the first he had been able to obtain from the Hebrides, and thus filling up a great blank in his work. It is not, however, the first that has been discovered in the Hebrides, as there is a Diatomaceous earth at Raasay, also in the Hebrides. This I have not yet examined, but I presume it has been described.

I beg to offer to the Society a few slides made, as I have stated, from a specimen of only middling quality, such as alone has been in my possession of late, and also a specimen of earth, not yet examined, in its natural state, which may possibly turn out good. I have added a portion of prepared earth in water, which cannot be cleaned from quartz fragments, but certainly contains a good many fine examples of the rare and beautiful *Pinnularia alpina*.

The subjoined figures are rough sketches of the doubtful form in the Mull deposit. They are represented with a power of 400 diameters. I find the length to vary from 1-470 to 1-600 of an inch. There are, as Mr. Smith first ascertained, 44 striæ in 1-1000 of an inch. It always exhibits the two notches towards the ends of the plane or slightly concave side. Fig. 1 is by far the most usual form; fig. 2 is, however, not unfrequent. The form is very abundant in the Mull deposit, and I have only seen it in one other, also from Scotland, namely in a slide labelled "From the banks of the Spey," which, I had from Mr. Topping. *Himantidium Arcus*, which, when small, has some slight resemblance to the above form, has only 22 striæ in 1-1000 of an inch and its striæ are consequently, *cæteris paribus*, quite easily seen, when those of the doubtful form cannot be made out. Mr. Smith thinks its place must be near *Eunotia Arcus*, Kützing=*Navicula Arcus*, Ehr.; but that it cannot be referred to that species. Indeed it is only very immature specimens of *E. Arcus* (Kütz.) that at all resemble this form, since the mature *E. Arcus* (Kütz.) has a bend or rounded angle in the middle. The doubtful form may be an immature one, but what is its aspect when mature?



On the Binocular Microscope, and on Stereoscopic Pictures of Microscopic Objects. By Professor C. WHEATSTONE, F.R.S. Communicated by Dr. Lankester, F.R.S. (Read April 27, 1853.)

IN Section 11 of my first Memoir on Binocular Vision, published in the Philosophical Transactions for 1838, I have alluded to the illusions to which microscopic observers are liable, from their inability to judge correctly the relief of objects when one eye only is employed. This indetermination of the judgment exists whenever a shadowless object is regarded with a single eye. Frequently an elevation appears as a depression, a cameo as an intaglio, a hollow pyramid (as a crystal of muriate of soda) as a pyramid in relief, &c., and *vice versâ;* but this indecision is entirely removed when the object is viewed with both eyes simultaneously. No mistake, if the object be a near one, can then be made with regard to its relief; and the relative positions of every point, in depth as well as in length and breadth, can be correctly determined.

The stereoscope affords a convincing proof that the two projections of an object presented to the two eyes, suggest the real object far more effectively to the mind than a single projection to one eye does; and those who have paid much attention to the appearance of binocular pictures in the stereoscope, will not have failed to remark, that not only is double vision of importance to enable us more accurately to judge of the relief of bodies, but it also occasions us to perceive things which pass entirely unnoticed when monocular pictures alone are regarded.

Fully impressed with these views, and convinced, from the reasons above stated, that a binocular microscope would possess great advantages over the present monocular instrument, I, shortly after the publication of my first memoir, called the attention both of Mr. Ross and Mr. Powell to this subject, and strongly recommended them to make an instrument to realize the anticipated effect; their occupations, however, prevented either of these artists from taking the matter up. The year before last, previous to the publication of my second memoir, I again urged Mr. Ross, and subsequently Mr. Beck, to attempt its construction, and for a short time they interested themselves in the matter, but ultimately relinquished it for want of time, and in my opinion over-estimating the difficulties of the undertaking.

It appears, however, from a communication in the 'American Journal of Science' of January, 1853, which has been reprinted in the last number of the 'Microscopical Journal,' that such an instrument has been actually constructed by Professor J. L. Riddell of New Orleans, and the results expected have been obtained. The method Mr. Riddell employs is similar to the one I recommended to Mr. Beck. After the rays from the object pass through the compound object-glass in the usual manner, he deflects them by means of a system of rectangular prisms into two directions parallel to the original, and sufficiently separated for the images to be seen by each eye. As in this arrangement there must be a considerable loss of light, I have proposed another which will not have this disadvantage, and which I will shortly submit to the Society.

A binocular microscope is, however, by no means a novelty, and its invention dates nearly two centuries back. I have found, in the library of the Royal Society, a work entitled 'La Vision parfaite, ou les Concours des deux Axes de la Vision, en un seul point de l'Objet. Par le P. Cherubin d'Orléans, Capucin.' This work was published at Paris in 1677, and in it eight chapters and a plate are devoted to a minute description of the instrument, which he informs us he constructed, and presented to the Dauphin. The following is an extract from the Preface:—

> " Some years ago I resolved to effect what I had long before premeditated, to make a microscope to see the smallest objects with the two eyes conjointly; and this project has succeeded even beyond my expectation, with advantages above the single instrument so extraordinary, and so surprising, that every intelligent person to whom I have shown the effect has assured me that inquiring philosophers will be highly pleased with the communication. For this reason I have determined to make it the principal subject of the present work."

And the second part, which contains a description of the instrument, is thus headed:—

> " Section the first, in which is taught the method of constructing a newly-invented microscope to see the smallest objects very agreeably and conveniently, represented entire to the two eyes conjointly, with a magnitude and distinctness which surpasses everything which has been hitherto seen in this kind of instrument."

In the Père d'Orléans' binocular microscope, two object-glasses have their lateral portions cut away so as to allow of close juxta-position, and these nearly semi-lenses are so arranged, that their axes correspond with the two optic axes passing through the tubes containing the eye-pieces. The author's aim in its construction was solely the reinforcement of the impression by presenting an image to each eye, for he assumes, according to the then prevalent error, that vision by the two organs conjointly is naturally and necessarily unique, from the perfect conformity of all the homonymous parts of the two images of the object on the two retinæ. The real advantage of such an instrument entirely escaped his attention; viz., that of presenting to the two eyes the two *dissimilar* microscopic images of an object, under precisely the same circumstances as the two unlike images of any usual object is presented to them when no instrument is employed, by which simultaneous presentment the same accurate judgment as to its real solid form, and the relative distances of all its points, can be as readily determined in the former case as in the latter.

In the construction of a binocular microscope there is one thing especially to be attended to—viz., that the images be both direct, for in this case only a true stereoscopic representation will be obtained. If the images, on the contrary, be inverted, a pseudoscopic effect would be produced which will give a very erroneous idea of the real form. The reason of these effects is fully explained in Sections 5, 10, 22, 23, of my Memoirs. The reversal of the images by reflection from mirrors or reflecting prisms, will produce the same result as to the stereoscopic and pseudoscopic appearances as their inversion by lenses. The binocular microscope constructed by the Père d'Orleans was pseudoscopic, though he describes one which, had it been made, would have been stereoscopic; he was, however, quite unaware that there would be any difference of this kind between them. The pseudoscopic effects when inverted images are presented, and the natural appearances when erecting eyepieces are employed, have not escaped the observation of Mr. Riddell.

Besides actual inspection by means of the binocular microscope, there is another way in which the advantages of binocular vision may be applied to microscopic objects. The beautiful specimens of photography, reproducing the highly magnified images of objects, inserted in a recent number of the Microscopic Journal, makes one regret that they were not accompanied by their stereoscopic complements. A very simple modification of the usual microscope would fit it for producing the two pictures at the proper angles; all that is necessary is to cause the tube of the microscope to move independently of the fixed stand round an axis, the imaginary prolongation of which should pass through the object. A motion of 15° would include every difference of relief which it would be desirable to have, and it is indifferent in what direction this motion is made in respect to the stand. The pair of stereoscopic pictures may be obtained by a still simpler method, which requires no alteration in the microscope; the object itself may be turned round on an imaginary axis within itself, from 7° to 15°. But this method is inapplicable unless the light be perfectly diffused and uniform so as to avoid all shadows, the presence of which would give rise to false stereoscopic appearances. In the former case, where the object remains stationary and the tube moves independently of the frame, the arrangement of the light so as to cast single shadows might be an advantage, and assist the visual judgment.

Quarterly journal of microscopical science