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ORIGINAL COMMUNICATIONS.

On the Development *of* Striped Muscular Fibre *in* Man, Mammalia, *and* Birds. By J. Lockhart Clarke, F.R.S.

(*Continued from page* 231, *vol.* ii.)

On the Development of Muscular Fibre in Man.

In man the development of striped muscular fibre is on the same plan as in birds and mammalia, but presents some points of difference that deserve consideration. In its early stage one does not observe those striking forms that appear in the chick between the sixth and seventh days of incubation (Pl. XI, fig. 9), and in the sheep or ox at a corresponding period. From the fourth to the fifth week of utero-gestation is about the earliest period at which this tissue can be distinguished with certainty from some others. In a fœtus of three fourths of an inch in length it forms a gelatinous mass, consisting, as in the other cases described, of fibres and nuclei imbedded in a semifluid, granular blastema. Pl. I, fig. 18 represents fibres from a fœtus three fourths of an inch in length; and fig. 19 both fibres and free nuclei from another fœtus, of one inch in length. In the formation of these fibres, as in similar cases already described, granular processes of condensed blastema extend from the sides or from around the nuclei; and along the surface of these a new substance forms, until they become partially or completely invested. At first the investing substance appears only on one side, in the form generally of a plain band or fibre (see fig. 18 *a*), but subsequently is seen also on the other. Sometimes, however, it is deposited in the shape of distinct, longitudinal fibrillæ, until the surface is completely covered (fig. 18 *b*); and sometimes these fibrillæ are at once or soon after divided into particles, which, when close together and on the same level, appear as transverse striæ (fig. 18 *d*). Seen under a power of 420 diameters, these two rows of particles had the appearance of short, transverse lines. On one side of them are the remains of the granular layer of blastema, ready to be converted into another fibrilla or row of particles. But even when the surface of the fibre is perfectly plain, with the exception of the two lateral borders, it may be resolved into fibrillæ by the influence of certain reagents, particularly chromic acid.

The diameter of the same fibre varies at different parts of its course, and the nuclei it contains are located at variable distances from each other. Sometimes, however, three or four are heaped closely together, one overlapping the other; and sometimes two are in contact at their edges, having just undergone the process of division. The fibres arrange themselves side by side, with the nuclear enlargements of one a little above or below those of another, so that their respective curvatures admit of their lying in close contact. Pl. I, fig. 19 *b* represents three fibres disposed in this way, but intentionally separated a short distance from each other. Sometimes they may be seen to increase in diameter or in the number of fibrillæ by the adhesion of fresh nuclei, from which new granular processes of blastema extend along their edges (fig. 20 *a*, *b*). Each of their lateral borders constitutes one fibrilla or more; but, except under the influence of chromic acid or some other reagent, it is only occasionally that the fibrillæ are resolved into particles or granules, which are in some cases exceedingly fine (see fig. 19 *a*).

The muscular tissue of the heart in the same fœtus differed in some respects from that of the trunk. The free nuclei were more densely crowded together, but the granular blastema was less abundant. All these bodies gave off processes, which, in many instances, were mere fibres, but in others they were broad at their attachment to one side or end of the nucleus, from which they tapered off into fibres, so as to present a funnel-shaped appearance (see fig. 21 *a*).* During the first formation of the muscular fibres the nuclei, with their processes, were disposed side by side, as represented in fig. 21 *b*. When formed, they were, in general, more uniformly granular than those of the trunk, more varied in shape, and irregular in breadth, and gave off branches by which they were connected in a kind of plexus or anastomosis. In some cases they were joined together by broad expansions of condensed blastema (something like the webb in a frog's foot), in which much finer branches might be frequently seen in

* From their appearance there is reason for believing that these funnel-shaped bodies are rudimentary nerve-cells in the substance of the heart; for they bear a striking resemblance to the rudimentary cells which I found in the intervertebral ganglia of the fœtus (see 'Phil. Trans.' for the present year, 2nd part). Some of the fusiform bodies belong to the tendinous tissue, and are of stronger outline than the others.

process of formation. Fig. 21 *c* represents different kinds of these fibres. In the bundles which they form they lie in such close apposition that they appear to be almost cemented together. One of these is represented at fig. 21 *e*. At its lower part the fibres have become separated. At the sides of such a bundle it was not uncommon to find oval nuclei with processes which divide into branches, as shown in the figure. Sometimes several nuclei appeared to be joined together by a condensation of the intervening blastema, in which at the same time a kind of plexus of fibres, of very small but variable diameter, became developed (fig. 21 *g*). In the heart the fibrillæ were much more frequently resolved into particles or sarcous elements, and therefore the appearances of transverse striæ were much more common than in the trunk.

In fœtuses of one and a half or two inches in length the muscular fibres of the trunk, which were first developed, had increased considerably in diameter; but many smaller ones were either formed or in process of formation. Fig. 22 represents several fibres in different states of development, from an arm of a human fœtus about two inches in length. Their increase in diameter depends, in some places, partly on a certain increase in the size of the nuclei which they contain, but chiefly on the deposition of new layers of the substance or the fibrillæ by which they are invested, and which, therefore, extend the breadth of the original borders. In the majority of instances these new layers are deposited nearly equally round the axis, but in many others they are added—at least for a variable length—more thickly on one side, as shown at *a*, fig. 22; so that from this cause, as well as from the size and relative distance from each other of the nuclei, the same fibre may vary in diameter at different parts of its course. It is flatter also in some parts, and gradually assumes a more cylindrical shape and uniform structure throughout its entire thickness. Numerous nuclei lie on its surface, along which granular processes may be frequently seen to extend from one to the other, as the foundation of new fibrillæ (see fig. 22 *b*). In all the larger fibres, and in most of those of intermediate size, the striæ are beautifully marked, but have often a different aspect in different fibres and in different parts of the same fibre. On each side of the axis there is commonly observed a very remarkable border of transverse striæ, corresponding to the plain lateral borders, and indicating the depth of the fibrillation. Fig. 22 *g* is an exact representation of a large and strongly marked fibre from the same fœtus. Its striated border, under a sufficient magnifying power, was easily resolved into several rows of sarcous particles, like those represented at *a*, *b*, fig. 20, in which, particularly, in *a*, if we suppose a number of other fibrillæ of the same kind to be deposited round the nucleus *a'* and its granular prolongations, we should have a general resemblance to the fibre now under consideration, in which it was easy to see, by changing the focus, that the whole of its upper surface consisted of fibrillæ similar to those at its sides. When the granular axis has disappeared, and the fibre throughout is composed of fibrillæ, and is therefore of uniform structure, the lateral bands, as bands, of course, disappear; while the nuclei, in many instances, reach the surface, in consequence of the unequal deposition of material around them. In other cases, however, the nuclei have seemed to disappear by breaking up into granules; but I am not sure that this is a natural histological change. In the embryo of the fowl, when the fibres are changing from the condition represented at *a*, fig. 12, to that at *a*, fig. 13 (Pl. XI)—that is, when the axis is disappearing, and the fibre is becoming a compact bundle of fibrillæ—the nuclei seemed as if they were escaping to the surface between the fibrillæ, as it were, by pressure, for many of them were partly between and partly without the fibrillæ. I have not witnessed the same appearances in mammalia, nor have I seen the same reed-like structure of the fibres as is represented at *a*, fig. 12, where the nuclei seem as if they were compressed by the lateral bands stretched over them at intervals.

Up to the time of birth nothing of importance remains to be observed. Fig. 23, Pl. I, represents three muscular fibres from the leg of a human fœtus of three and a half months; one of them is left blank.

Such are the results of my own observations on the development of striated muscular fibre. Let us now consider how far they agree with the theories and observations of previous inquirers.

It is well known that, according to Schwann, every muscular fibre is at first developed from round nuclear cells, which arrange themselves in linear series and coalesce at their points of contact. The septa by which they are separated then become absorbed, so that there results a hollow cylinder,—the secondary cell of muscle, within which the nuclei of the original cells are contained, generally lying near together on its wall.*

In 1849-50 Lebert published some investigations on the development of the same tissue in vertebrate animals,† opposing at the same time the theory of Schwann. Speak-

* 'Microscopical Researches,' &c., p. 141.
† 'Annales des Sciences naturelles.'

ing of the origin of the muscular cylinders, he says—"J'avoue que la théorie cellulaire ne me rend pas bien compte de leur première formation, et je n'ai pas pu confirmir leur mode de développement par alignement et fusion de globules, mode indiqué par plusieurs physiologistes distingués."* According to him, the first traces of the muscular fibres make their appearance as fusiform, somewhat oval, cylindrical, or irregular corpuscles or cells, which he calls the myogenic bodies, and in which certain indications of longitudinal striæ are already observable; ("corpuscules fusiformes, ovoides ou irréguliers;" "corps ou cellules myogéniques;" "espèces de longues cellules irreguliers"). He confesses, however, that he was unable, by direct observations, to determine the mode of origin of these bodies—"dans l'oiseau, comme dans les autres vertébrés, la première origine des cylindres musculaires ne peut pas encore être précisée par l'observation directe."† It seemed to him that they were formed by a coalescence of all sorts of pieces, and that the nuclei within them were only accidentally inclosed.‡

It is evident that the "corps ou cellules myogéniques" of Lebert correspond to the bodies which I have described and represented as appearing in the chick between the sixth and seventh day of incubation (see Pl. XI, fig. 9, *c*, *d*, *e*, *f*); but of their mode of origin, as already shown, he was unacquainted. Neither does he make any mention of the smaller fibres which are formed at an earlier period, as I have already described.

In 1854 a paper, by Mr. Savory, of London, "On the Development of Striated Muscular Fibre in Mammalia," was read before the Royal Society, and in 1855 was published in Part II of the 'Phil. Transactions.' The results of these investigations are completely at variance with the cell theory of Schwann. The following is a brief statement of the principal facts connected with the plan of development.

The first stage consists of the *aggregation* and *adhesion* of the free cytoblasts or nuclei into clusters, and their investment by blastema to form elongated masses, which are irregularly cylindrical or somewhat flattened. The nuclei thus aggregated next fall into a single row, while the surrounding substance at the same time grows more transparent, and is arranged in the form of two bands, which border the fibre, and increase in thickness by the addition of fresh blastema to their external surface. The fibres next begin to lengthen, while their nuclei part from each other, and as the distances

* 'Annal. des Sciences nat.,' 1849, p. 352.
† Ibid.
‡ Ibid., p. 377.

between the latter increase the bands which separated them fall in and coalesce, so that the diameters of the fibres decrease. Soon after the nuclei have separated some of them begin to decay by breaking up into irregular clusters of granules, which themselves soon disappear. At this period the striæ first become visible within the margin of the fibre, and then pass gradually towards the centre. The fibres now begin to increase in size by means of the surrounding cytoblasts. These become attached to their exterior, and invested by blastema, which generally forms a continuous layer between them. The nuclei subsequently sink into the substance of the fibre, and an ill-defined elevation, which soon disappears, is all that remains.

Now, while this account and that which I have given as the result of my own investigations differ from each other in many particular points, they still very nearly coincide in regard to the general principle or plan upon which the fibres originate in the blastema. In the first stage of their formation, however, the nuclei are far from being always aggregated in clusters, or even in contact with each other in linear series, as may be seen in birds, mammalia, and especially in man, in whom such an arrangement never occurs (figs. 4, 5, 14, and 18); and even when they are in contact or overlay each other their adhesion always takes place by means of a certain quantity of blastema, as at *c*, figs. 5, 6, and 14. When they are at some distance from each other, the blastema which cements them in a larger or smaller quantity is more or less enclosed as an axis by the condensed substance of the lateral bands, and contributes to the extension of these bands or to the formation of separate fibrillæ around the rest of the fibre, which, however, increases in *diameter* by the deposition of fresh material on its surface (fig. 4 *a*, *b*, *c*; fig. 5 *a*, *b*, *d*.) In many instances, particularly in the younger fibres, the nuclei are crowded together in close contact, as represented by Savory, and sometimes they overlap each other, as represented at *c*, fig. 5. When several of them are compressed closely together they frequently seem as if they were undergoing a process of division, and such a process does actually take place in many instances within the fibres, where the nuclei frequently occur in pairs or in rows of three or four.

My observations on the first stage of development of muscular fibre in the *human* fœtus, with many of the drawings, were made at the beginning of the present year (1861). Those in the chick I made in the following June and July; and while occupied with the same subject in mammalia during the month of October, my attention was directed to a recent paper on the development of striated muscular fibre by Deiters, of Bonn.* This author's observations were made on the tissue formed during regeneration of the tail of the tadpole. The conclusions at which he arrives are as follows:

1. Striated muscular fibre results from the transformation of a structure belonging to the class of connective tissues.

2. This transformation proceeds directly from the connective-tissue-cells, which, however, preserve their spindle and stellate shapes.

3. The essential nature of the process consists in this—that the cells deposit the striated substance on their outer cell-wall, so that it possesses the relation of an intercellular substance.

4. This substance shows itself at first in the form of a simple, long, smooth, and frequently transversely striated band or border of condensed material (Verdickungssaum), which corresponds to our fibrilla, and increases by the continual deposition of new layers on its outside.

5. The deposition takes place mostly on one side, but may occur on other sides.

6. During this process the cells multiply by a considerable increase in the number of the nuclei. At the same time the striated border increases in length, and may extend very far beyond the cell.

7. The cells do not lie immediately behind one another, but either side by side or obliquely behind each other, somewhat in the fashion of tiles.

8. The formative cells are connected with the connective-tissue-cells of the tendons.

9. The sarcolemma is the last product of the developed primitive bundles; it is not cell-membrane.

From some of these statements it is obvious that, as regards the manner in which the muscular fibres first make their appearance in the blastema, there is a general coincidence of this author's views with those put forth by Savory, as well as with my own. The chief points of difference are the following:—1st. That although, according to Deiters, the muscular fibres are not formed *directly by the coalesced substance* of nucleated cells, as maintained by Schwann and others, yet that nucleated *cells* are the real agents in their development. 2nd. That these "formative cells" are not

* 'Beitrag zur Histologie der quergestreiften Muskeln,' von Dr. Otto Deiters. Reichert's u. Du Bois-Reymond's 'Archiv,' Heft iii und iv.

ultimately inclosed by the striated substance to which they give origin.

With respect to the first of these statements, the question to be decided is, whether these formative bodies are to be regarded as true nucleated *cells*. In the regenerate tissue of the tadpole, according to Deiters, they are real *cells*, possessing distinct envelopes. Now, although in this particular case I am not prepared to offer any opinion from direct observation, since the season had already passed for making the necessary examination before the publication of the Deiters' paper, yet I think I may safely assert that in man, mammalia, and birds, the granular substance surrounding the nuclei, and concerned in the development of the muscular fibres, have *no envelope or cell-wall* in the proper sense of the word, and that these bodies are not entitled to be considered as nucleated *cells*.* It is true, as I have already shown, that the granular substance sometimes assumes the form of a fusiform cell; but, if the process of development be examined in very young embryos, the tapering or conical prolongations of the nucleus may be observed in different stages of formation, and to consist frequently, at first, of delicate streaks of the finely granular blastema. But it very commonly happens, as I have also shown, that the intervening blastema cements the nuclei together, without forming a separate mass around each. In other instances, as represented at *e*, fig. 11, in the chick, and at *m*, fig. 14 (Pl. XI), in the pig, a fibre originates in the blastema, between series of nuclei, at some distance asunder, which are each connected with the fibre by a more or less globular, oval, or fusiform mass. Fig. 14, like the others, is an exact representation of a fibre from the dorsal muscles of a fœtal pig of not quite an inch in length. The granular blastema on the left border of the middle nucleus had not yet actually assumed the appearance of a fibre. The free edges of these delicate and variously shaped masses of blastema are at first frequently uneven, ragged, or, at least, not sharply defined, and contrast strongly with the very distinct and well-defined wall of the nucleus itself. But when a fine fibre or lateral band has formed along each side of one of the masses surrounding the nucleus, and has joined its fellow at both ends (as at the lower part of *m*, fig. 14; the upper part of *e*, fig. 11, and elsewhere), this investing substance has

* It is necessary to state that an abstract of my present communication was received by the Royal Society of London, on November 21, 1861; read January 16, 1862; and published in No. 48, vol. xi, of the 'Proceedings of the Royal Society.'

frequently the appearance of a cell-*wall*, so that the body might be taken for a true nucleated cell, giving origin to a process or fibre. Such would be the case at *f* and *g*, fig. 14, if the lateral band were a little finer, and were joined at each end of the mass by another from the opposite side. I have examined such a multitude of specimens from embryos of all ages, with so much care, that I can scarcely see how any unbiassed and candid inquirer, who has devoted the same attention to the subject, can arrive at any other conclusion than the one I have just drawn.

In the opinion of Deiters, the muscular fibre and striated mass is to be considered in the light of an intercellular substance, *secreted* by the so-called nucleated cells. Whether it be a product of secretion or not, I leave out of the question; but supposing these bodies to be true *nucleated cells*, with cell-walls, it is quite certain that their *separate* existence, *as such*, is far from being a necessary condition for the development (secretion) of the muscular fibres; for by the descriptions and figures of Dieters himself, it is shown that several of these cells frequently *coalesce* to form either a continuous band or tube,—in which the nuclei are disposed in linear series,—or an irregular mass, in which they lie without any order, so that in these cases the process of secretion would be carried on, not by separate cells, but by tubes, bands, or irregular masses formed by the *coalescence* of cells. However, there is little doubt that the muscular substance is the result of some process carried on by the *nuclei* themselves. Now, according to my own opportunities of observation, the *organic* muscular-fibre-cell is developed on the same plan as the *striated* fibre in its first stage, viz., by the formation of sarcous substance around a nucleus encrusted with blastema; so that the latter kind of fibre, instead of being the *product* of a nucleated cell, would appear to be itself a kind of cell-*formation*, which at first finds its prototype in the *organic* muscular-fibre-cell, and in which the investing sarcous substance represents the cell-*wall*.

On the General Anatomy, Histology, *and* Physiology *of* Limax maximus (Moquin-Tandon). By Henry Lawson, M.D., Professor of Physiology in Queen's College, Birmingham.

It has often occurred to my mind that the objects by which we are almost invariably surrounded are not unfrequently those with whose characters and history we are least acquainted. How many are there who, though on terms of intimacy with the utmost minutiæ of some arabesque, or specimen of mediæval ornamentation, can accurately depict from memory alone the pattern of a well-known carpet or the design of a drawing-room's tapestry? If so commonplace a comparison be not inadequate to the subject, I beg to offer it as one of the circumstances which instigated the researches, upon which the results stated in the following pages have been based.

The variety of *L. maximus* selected for dissection has been in most instances the dark one, with occasional examinations of the mottled specimens; the chief morphological distinction between the two, being the possession by the latter of a distinct shell, the material of which in the former is usually found in a condition of disintegration, mingled with the mucous exudation of the sac in which it is contained. We find, according to the philosophic investigations of Prof. Huxley,* that the slug, like other pulmonata, develops in the embryonic state, an abdomen or mass of tissue anterior to the anal aperture, in this way causing the intestine to bend, with its concavity facing the nervous region of the body, and hence it comes under the category of molluscs, exhibiting a "neural flexure" of the archetype of this naturalist.† The arrangement of the organs included in the economy of gasteropodous creatures is generally stated to partake of irregularities, to be devoid of co-ordination, and to be asymmetrical. I cannot say that I have been forcibly impressed by the truth of these dogmas, for to me, a very decided symmetry is apparent, and that too, in many instances, of the bilateral type. Thus, in the nervous, the circulatory, and the special sense systems,

* "On the Morphology of the Cephalous Mollusca, as illustrated in the Anatomy of certain Heteropoda and Pteropoda collected during the Voyage of H.M.S. 'Rattlesnake.' By T. H. Huxley, F.R.S." 'Philosophical Transactions,' 1853.

† Some difficulty is at first experienced in endeavouring to realise this change, but the author's explanation (*vide* note, p. 51, of memoir referred to) renders the matter most explicit.

we find the constituent organs equally divided between the two sides of the body, and there are two salivary glands and two principal divisions of the liver, one of each lying on either side of the median line. The lungs we may also, to some extent, distribute with reference to a central plane; and, finally, there remain but the generative and digestive apparatuses, which, though seemingly aberrant, we are not warranted in concluding to be asymmetrical till better acquainted with their phases of development. In a rude way we may look on this animal as a tough, elongated pouch, containing viscera, and having attached to its dorsal surface, on its anterior third, a convex and in some measure pyramidal cap, which is composed of the so-called mantle; this, in vertical section, is dome-shaped, and is a perfectly closed cavity, in which is placed the loose mass of calcareous particles of the shell; below, it is limited by a delicate, transparent membrane, which lies upon the heart and pericardial gland, and appears by a process of splitting to pass beneath these latter also, in this manner completely separating them from the great visceral chamber subjacent (see Pl. II). I propose to treat of the anatomy of Limax after the following scheme:

1. Tegumentary system.	5. Circulatory system.
2. Muscular system.	6. Nervous system.
3. Digestive system.	7. Special sense and gland system.
4. Respiratory system.	8. Reproductive system.

Integument.—The skin system is of the musculo-cutaneous type, and may be said to consist of three coats, an outer or dermoid, a middle or muscular, and an internal or fibro-vascular, and calcareous. The first resolves itself into two layers, a more external stratum, which is transparent, and, so far as I could observe, structureless, and in some instances detachable, and within this a bed of fusiform endoplasts, imbedded in a clear matrix, and which assume the fibrous appearance of connective tissue as they approach the next coat, from which they are inseparable. The muscular or central lamina is also composed of two layers of fibres, the most external being longitudinal, and those within them transverse, yet the line of distinction cannot be clearly drawn, for as you advance inwards you find the outer fibres gradually losing the longitudinal and by assuming an oblique position, in this way passing almost insensibly into the truly transverse ones; the fibres, at best, are indistinct, and are composed of elongate endoplasts. The inner coat consists of meshes of connective tissue, tunneled for the conveyance of the venous blood, and impregnated with round, granular particles of carbonate of lime, which give that portion lining the visceral chamber a pure, white, lustrous aspect. I have not entered into the shell question in these pages, because the shell in its mature form is more or less structureless, and its homologies can only be arrived at by an appeal to development, the study of which in this animal I have not devoted sufficient attention to.*

Muscular System.—The muscles in this animal are not numerous, as, indeed, they are not in any mollusk, and may be conveniently grouped under two heads—those blended with the integument, and those distinct. The former I have already described. The isolated muscles are very few in number, and embrace those of the tentacula, and the retractors of the head. In both cases they are flattened bands, of a glistening, semi-transparent appearance, and are made up of long, fusiform endoplasts, with dark nuclei, and surrounded by a clear periplast. The retractor of the head is a long, tough, flat band, which arises from the integument of the right side, about the middle of the antero-posterior plane, and, passing beneath the viscera reaches the nervous collar of the gullet; here it comes through the circlet of nerves and beneath the œsophagus, and on approaching the head bifurcates, the two filaments thus produced being inserted into the musculo-fibrous tissue of the head, with which they become continuous. The tentacular are much more complex in mode of arrangement, and are three in number for each side of the body. These three are united in such a manner as to give rise to a more or less perfect equilateral triangle, whose base lies in the longitudinal plane, with the apex pointing laterally and a little upwards; the posterior extremity of the base is continuous with the dense skin of the foot, to which it is attached, and the anterior side is prolonged and blended with the tissue of the foot in the median line and just below the mouth. From the apex of the triangle springs the superior tentacle, and from the muscle constituting the base arises the inferior one; hence, if the basal cord contracts, the superior tentacle will be drawn in; if the posterior side of the triangle is shortened, the inferior tentacle will be brought in; and should the anterior band be stimulated, it will tend more or less by its contraction, to place both tentacula in a position to allow of eversion by the usual means. A glance at the semi-schematic figure on Pl. II will suffice to make these remarks intelligible.

* For an admirable memoir on this subject, consult "Beiträge zur Entwickelungsgeschichte der Land-Gasteropoden," by Carl Gegenbaur, in Siebold und Kölliker's 'Zeitschrift,' &c., for 1852.

The Digestive System, with the appendages which appertain to it, forms the bulk of the slug's viscera, and in treating of it we have to speak of the following parts:—head, salivary glands, gullet or pro-stomach, stomach, liver, and intestine. The head is the most anterior portion of the body, and when deprived of the tentacula and integument which cover it appears as a solid, glistening, white structure, of a more or less spherical form, viewed from above, in profile seeming oval, the large end behind, and having, projecting from its posterior inferior border, a small, whitish, semi-transparent papilla. On its two sides, above, are seen the superior tentacles, and beside and beneath, various branches from the cephalic or supra-œsophageal ganglia; moreover, the two most anterior ganglionic masses are strongly united to its external lateral surfaces, and their branches wind around it as before described. It is about $\frac{1}{4}$ inch long in an antero-posterior direction, and measures $\frac{1}{5}$ inch transversely. Interiorly it is hollow, has in front an aperture—the mouth—and receives at the most superior border of its posterior surface the commencement of the gullet; its cavity resolves itself distinctly into two—the upper or true mouth, and the lower or pharynx—which must be described separately.

The mouth lies superiorly, and has its position indicated by the conception of a right line uniting oral orifice and gullet, and which is horizontal; the outer opening is provided below with a fleshy lip (a modification of the general integument), which is partially divided by vertical slips into squarish segments, and plays the part of an inferior jaw. Above, the lip is absent, its place being taken by a very distinct and perfect maxilla. This is a horny or chitinous structure, about $\frac{1}{8}$ inch wide and $\frac{1}{6}$ inch long, which is soldered to the palate; it is of a brownish colour, and of a somewhat triangular outline, the base in front notched, and bent downwards at right angles to the rest, thus performing the office of teeth; the apex pointing to the œsophagus, and the whole non-dental surface constituting, as it were, a second palate; behind, and close to its junction with the gullet, are seated the openings of the salivary glands.

The pharynx or inferior cavity is a kind of pocket or diverticulum, which I can compare only to an inverted and bisected hollow cone, flat behind and angular in front; it is lined with a roughened membrane, and has, pointing from it downwards and backwards into the visceral cavity, the papillary process above alluded to, which organ can, by an eversion, be brought forwards so as to lie obliquely in the pharyngeal sac. The roughened membrane with which the pharynx and tongue (for so the papillary organ must be termed) are covered, when seen under the microscope, is a very pretty object. It is covered by a multitude of closely set spines of a calcareous nature, arranged in linear order, side by side, the lines being placed one behind the other; each spine consists of a central portion or body, which is elliptical, and an exquisitely slender curved hooklet springing from this latter; the points of the hooklets all project backwards, and the spines are placed one behind the other, and *not alternately*, with an exceedingly small, rounded process rising from the membrane between every pair. The functions of the head are two, those of prehension and mastication, deglutition being achieved through the contractions of the gullet. Now, the first, as I take it, is performed by the jaw and lips, which, grasping the leaf or other portion of vegetable matter, bring it within reach of the pharynx; arrived here, it is acted on by the salivary fluid which has been thrown into the pharyngeal bag, then by a series of compound movements of the tongue it is submitted to a rasping process between the hooklets of this latter and those of the pharynx, and eventually, having been reduced to a state of very fine division, it is tilted backwards by the tongue, and being now within the grasp of the œsophagus is gradually carried onward to the stomach. The head is principally composed of connective tissue, but about the oral orifice on the inferior border, a considerable band of nucleated, unstriped fibres may be observed; a few fibres of a similar description are mingled with the layers of connective web, and the tongue [beneath the spinous coat] is almost entirely muscular.

The salivary glands are two in number, extremely delicate in texture, and of a pale-white colour; they lie on either side of the œsophagus, in the respiratory region, being covered by the heart and pericardial gland, and resting in part upon the great supra-œsophageal ganglia; they are bound to the gullet by numerous arterial branches common to both, and are flattened and leaf-like in appearance. Each gland has a length of $\frac{5}{8}$ inch, from side to side measures about $\frac{1}{4}$ inch, and pours its secretion into the mouth by a long and narrow duct, which passes anteriorly from the gland, beneath the great ganglia, to the orifice of the gullet immediately above the pharynx, and in which I, less fortunate than Müller, have not detected ciliated epithelium. In general structure these glands are loose, and are made up of a number of minute lobules, arranged in clusters upon the terminal ramifications of the ducts. Microscopically, each lobule is of an oval shape, filled with transparent fluid, and contains, floating in this latter, many well-marked circular endoplasts, with nuclei in their interiors, and has attached to its inner edge a delicate twig from the excretory duct (Pl. II, fig. 3).

The gullet is a canal, at first narrow as it leaves the mouth, but having passed the nervous collar it widens so as to resemble a funnel, and its walls become more dense and muscular; it is usually of a dark-brown colour, this being for the most part owing to a quantity of bile, which it nearly always contains, and which renders it not unlikely that much of the true digestive process is gone through here. Like the other division of the alimentary canal, the œsophagus exhibits the tendency to curve spirally in its passage from head to stomach, and though prior to its passage through the second nervous circle it is horizontally situate in the median line, yet, between this and the stomachal sac, it turns to the left and downwards, and again bending to the right in the central axis and, equidistant from the head and caudal extreme of body, it terminates in the stomach. It is related above to the heart, pericardial gland, lung-sac, nervous masses, anterior lobe of liver, and large and small intestines, the rectum just passing over it between the head and ganglionic centre; it rests upon the foot (having the pedal gland below it) and inferior nervous masses; is bounded on the right by the anterior portion of the reproductive organs, on the left by a fold of the large intestine, and on both sides by the tentacula and their muscular apparatus. It is little more than two inches in length, has a calibre of $\frac{1}{6}$ inch at the cardiac orifice of the stomach, and measures diametrically $\frac{1}{12}$ inch as it leaves the mouth. Histologically, the œsophagus is identical with the other divisions of the alimentary canal except the stomach, and therefore the sketch of its microscopic anatomy will suffice for all, except the latter. Two coats enter into its composition, a fibro-muscular and pseudo-mucous, neither of which, however, can be detached without injury to the other. The first, most external, or visceral layer, when examined under a low power, presents to the eye a collection of muscular and connective tissue fibres, nerves, and blood-vessels, mingled heterogeneously together; but if the larger branches of the latter be carefully teased out, and a small section submitted to a much higher power, it is then seen that the outer coating is composed of two distinct strata of nucleated, non-striated, muscular fibres, crossing each other pretty nearly at right angles, and, blending with them and pursuing an undulatory course, a few fibres of the elastic connective tissue (fig. 4). The muscular fibres are absent in some localities, thus leaving small rectangular spaces between the strata. The second lamina is with difficulty prepared for examination; it is perfectly transparent, and, so far as I could observe, entirely devoid of epithelium, ciliated and non-ciliated, and perfectly structureless, seeming to be a kind of protective glazing, thrown out over the external coat.

The stomach is an oval-shaped bag, of a dark-brown colour, into one end of which open together, the gullet and intestine, so that these latter appear almost continuous, and the stomach itself looks as though it were a diverticulum (fig. 1). It is placed in the centre of the antero-posterior plane, inclining a little to the left; to its dextral end are attached the gullet and intestines, its sinistral extreme being free; it is supported by the foot and oviduct, has the ovary behind, the two bile-ducts in front, and the liver on either side and on its superior edges. Above, it is in relation to the inner surface of the integument only, and therefore it is one of the structures seen on removing the dorsal covering. It is about $\frac{1}{2}$ inch long, $\frac{5}{16}$ inch deep, and $\frac{1}{4}$ inch wide. As in the gullet, so here, we have two separate laminæ—the outer or muscular, the inner or mucous. The external coat is made up of three rather well-marked, muscular layers—circular, longitudinal, and oblique—which present the same appearance as those of the œsophagus, with this exception, that, whilst the nuclei in the fibres of the latter were short, in those of the stomach they are large, distinct, and fusiform; the inner layer is nothing more than a bed of oblong endoplasts, resting upon the outer; a zone of indifferent tissue, or a protomorphic line (to use Prof. Huxley's expression), being interposed.*

The intestine is a tube, musculo-membranous in character, as wide as the gullet for about one third of its length, but gradually diminishing in diameter as it approaches the anus; from this peculiarity, that portion of the gut which is nearest the stomachal cavity must be termed the larger, and the remaining division of the canal the smaller intestine. Except toward the anal aperture, it is of a dark, brownish-green colour, which is due in some measure to the vegetable and biliary contents. In its entirety it averages a length of seven inches, is of equal capacity with the gullet as it leaves the stomach, and measures not more than $\frac{1}{10}$ inch at the anal orifice. It is better, in treating of its relations, to assume that it is a single tube, and in this way avoid the difficulty of drawing the exact line between the greater and lesser gut. The intestine, then, leaving the pyloric end of the stomach, travels obliquely, forwards and upwards, beneath the liver, and

* I have not seen the spinous coat, so often alluded to in popular treatises on microscopic anatomy.

above the œsophagus, where it is covered by the integument only, to the right lateral respiratory region; arrived here, it makes a sudden turn, and passes beneath the gullet to the left; next it curves slightly upwards and then downwards—still being upon the left—and descends again, coursing beneath the œsophagus and toward the right side; it now ascends, and, going to the left above the gullet and below the liver, it is lost sight of; continuing its course upon the left, it approaches the stomach, its convexity reclining against this organ. At this point, by a perfect sigmoid flexure, it encloses a portion of the liver (being still, however, beneath the upper part of this latter), winds to the right across the œsophagus, and, passing under one of its own folds, and, finally, beneath the heart and pericardial gland and above the gullet, it terminates in the anus at the superior angle of the pulmonic orifice, being here retained *in situ* by the united muscles of the retractor capitis, which are looped around the gut. The anus is closed by a circular band of elastic tissue, which encircles this tube at its junction with the integument.

The liver is by far the largest and most complete gland in the economy of this animal, and when separated from the other organs with which it is connected, appears as two separate structures, exhibiting what we should not have been led to expect, similarity of size and form; these are of a dark-brown colour, and have their under surfaces crowded with exquisite white, arterial ramifications. The liver shows the general tendency to assume a twining arrangement, for we find it adapting itself to the various folds of the intestine, and so embracing the latter, that, a separation of the two involves some delicate dissection. Each lateral division is conjoined to the stomachal end of the œsophagus by its wide and easily distinguished hepatic duct; that of the left side pouring its secretion into the gullet about $\frac{1}{6}$ inch anterior to that of the right. Each is of an irregular oblong shape, bearing *some* likeness in outline to a lanceolate, acute leaf, with notched edges, and consists of numerous large and small lobes, bound loosely together by a web-like connective tissue, and attached to branches of the principal duct; it measures about 2 inches in length, and at its widest part is more than $\frac{1}{2}$ inch in breadth, but in some specimens which I examined the liver did not exceed 1 inch in length, and was proportionally narrow. Every lobe may be divided into a number of component lobules, and each of the latter comprises seven or ten still smaller structures of an uneven polyhedral type, within whose walls may be observed numerous endoplasts, some of them large, with yellow or light-brown contents, others small, without nuclei, and also a considerable amount of loosely floating granular particles. The duct, on entering one of the lobules, divides into several branches, which surround the many-sided compartments, and become eventually indistinguishable from the fibrous septa; but never have I detected a communication between duct and theca, the two portions of the organ being as separate as they are in the human liver, according to the view of a recent investigator.* Had there been any distinct connection, it could not have remained unobserved, since it is easily perceived when it does exist, as in the salivary gland. The bile is a dark-brown liquid, with a faintly unpleasant odour and a nauseous sweetish taste, which is poured in large quantity into the gullet when the animal has been without food for some days. Under the microscope it seems a transparent fluid, suspending many clusters of brown granules, and nucleated and non-nucleated endoplasts.

General remarks.—Lebert, in a communication to Müller's 'Archives' for 1846, has given many figures of the head, tongue, and spinous membrane of Limax, but in some instances, I conceive, he has not accurately depicted the structure and form of these organs. The palate, judging from his sketch, seems but a mere slip proceeding from the central portion of the jaw, which is not the case, the whole palate and jaw forming, when flattened out, a complete triangle, two of whose sides are slightly concave outwards. Again, he has certainly mistaken the arrangement of the processes attached to the lingual membrane, inasmuch as he has placed them in alternate rows, and has omitted the intervening mammillary elevations. The head, also, I fancy, is too much prolonged. Finally, his representation of the muscular fibre I cannot reconcile to anything I have perceived. It might, at first sight, seem difficult to put faith in Mr. H. Jones's views of the liver's functions, the conditions under which the hepatic circulation is carried on here being different from those we meet among vertebrata, but this apparent difficulty disappears when we know that if the *special secretion* were thrown out into the visceral cavity, it would at once be taken up by the veins.

Respiratory System.—The function of respiration is carried on by means of atmospheric air introduced into a special cavity, containing numerous blood-vessels upon its surface,

* "On the Structure, Development, and Function of the Liver." By C. Handfield Jones, M.D., F.R.S. 'Philosophical Transactions,' 1853.

and this cavity is termed the lung. The respiratory organ is usually described as being a ring surrounding the heart; this, however, is not correct; it is a double sac, one pocket of which is situate on the right, and the other on the left side, having two channels of communication, by means of which the air is conveyed to every portion of the vascular surface. These pouches are placed in the thoracic region of the body (fig. 5), and are constituted externally of the general integument, and within of a delicate fibrous membrane, which also serves to define their limits; their upper borders are bounded by the inferior surface of the shell, and below they are separated from the viscera by a septal fold of their inner membrane, which also forms a posterior partition between the lung and abdomen; anteriorly they are closed in by the same structure, and internally they are related to the heart and pericardial gland, which are placed between the two sacs. The connecting channels cross the body, one in front of the pericardial gland and heart, and the other immediately behind them. The air is admitted through an orifice of an elliptical or doubly cuneate form, which is upon the right side near the middle lateral line, and at about $\frac{1}{2}$ inch from the right upper tentacle. The great veins which convey the blood to the lung are two in number, one for each of the pockets, in the external walls of which they are grooved, being merely, as it were, ploughed channels in the integument, which have been covered in by fibrous membrane. Each sends off several branches from its upper and lower edge, which respectively pass upwards and downwards, curving in their course, with their concavities facing each other, and terminate in the border of the pericardial gland. In the outer portion the vessels are, as I mentioned above, but passages in the integument (which here, from the particles of carbonate of lime imbedded in it, is white, as in the other regions of the body), but internally they lie between two transparent layers of membrane, and from this circumstance are easily observed in their passage to the pericardial gland. Each division or sac of the lung measures about $\frac{1}{2}$ inch in length, and is a little more than a $\frac{1}{4}$ inch from above downwards. The width is variable, depending, as it does, upon the condition of the body as to contraction or elongation. The course of the blood through the pulmonary vessels is more properly described under the head of—

Circulatory System.—The course of the blood, in its passage through the bodies of molluscs, has long been misunderstood. Heretofore it has been thought that a perfect circulation existed, that is to say, a complete series of channels, by which the nutrient fluid was conveyed from the propelling organ to the various regions of the body, and returned to the heart. Milne Edwards* has done much to correct the errors of the earlier investigators; but as his observations do not extend to Limax, and since the latter genus and that of Helix, the course of whose circulation has been traced, are so widely distinct anatomically, the mode in which the blood is carried to and from the heart and pulmonary organs of the slug, has not as yet been distinctly explained. I have most carefully pursued the examination of this subject, occasionally with the assistance of injections prepared with new milk, and the result has been the adoption of the following view. The blood, having been expelled from the heart, travels through the short aorta and its two divisions, in this way reaching the head, reproductive organs, intestinal sanal, and liver, and, having arrived at the terminal ramifications of the arterial vessels, is poured through their open extremities into the abdominal and sub-thoracic cavities, thus bathing the external parietes of the viscera; these cavities are continuous, and clothed without by the general integument, in whose walls the various channels are tunneled. Now, the veins begin as minute apertures,† which admit the blood hitherto contained in the visceral chamber, allowing it to pass into their smaller branches; from these it then flows into the larger vessels, and is finally transmitted by the great pulmonary vein of each side, to the respiratory sacs. It is here that difficulty has been invariably experienced, in tracing the channels by which the blood travels to the heart, some contending that a portion flowed to the so-called kidney, whilst the remainder was brought on to the heart by a large pulmonary vessel; others that the blood was here poured into a sinus or lacuna. Both these ideas I conceive to be erroneous, the more so as I have been unable, after the closest scrutiny, to detect any single pulmonary vessel which might of itself convey the blood to the heart; and besides that, the relations and character of the *quasi* kidney have been most certainly misinterpreted. The circulation in this locality is most complete and peculiar, and can be seen with more or less distinctness by removing the mantle, and membrane of the shell-sac. When this has been done, it will be observed that the blood travels in the direction I have endeavoured to indicate diagramatically (fig. 6), viz., having been poured by the

* 'Ann. des Sci. nat.,' viii, 1847.

† The merit of this discovery is, I believe, due to Cuvier; *vide* for Aplysia, 'Ann. du Mus. d'histoire nat.,' ii, p. 299.

great pulmonary vein of either side into the numerous lesser ramifications of the lung-membrane, and been in this way fully exposed to the atmospheric air, it flows in two principal directions, according as it has passed from the upper or lower borders of the great lateral veins. That which has been sent upwards travels in obedience to the limits of the pulmonary sac, first superiorly, then horizontally, and finally inferiorly, till it gains the external edge of the pericardial gland; and conversely, that which left the under surface of the vein courses first inferiorly, then horizontally, and eventually ascends, till it arrives at the same position as the rest. Here, then, we find all the blood which has traversed the respiratory reticulation at one period or other of its career, and from this it passes internally, through the pericardial gland, in a perfectly centripetal manner, till it has reached its inner border; this latter expands, and constitutes, by a double, sector-like fold of membrane,—whose arc is confluent with the anterior division of the gland, and the junction of whose sides is intimately attached to the heart,—a capacious sinus. Into this expansion the blood is next introduced, flowing readily into it at its immediate union with the gland, and being conveyed from the posterior internal border of the latter by a canal partly circular, whose concave edge lies against the heart, whose convexity is continuous with the gland, and whose two orifices open into the lacunal cavity referred to. From the sinus the blood is transmitted to the heart by an aperture of communication between the former and the base of the latter. Finally, by the contractions of the heart it is propelled onwards through the aorta and its divisions (regurgitation into the sinus being prevented by a small fold of membrane acting as a valve) to the different systems of organs, and so on, as before. The heart is a thin muscular bag, of a somewhat triangular or pyriform description, and of a faintly marked flesh-like colour; it is placed in the thoracic region, being surrounded by the pericardial gland, bounded below by the fibrous membrane separating the heart-chamber from the visceral sac, and above by the floor-tissue of the shell-bag; it lies obliquely, its apex pointing backwards and to the right, and its base in the opposite direction. It measures a $\frac{1}{4}$ inch in length, and $\frac{1}{6}$ inch or thereabouts in width. It is wrong to describe the heart as being composed of an auricle and ventricle; it is a simple bag, having but one cavity, and not presenting any division, either by constriction or otherwise. It is almost wholly formed of non-striated muscular bands, interlaced in the most complex manner, and freely united to each other at their extremities.

The fibres, if they may be so termed, are filled with long, spindle-shaped endoplasts, containing clear nuclei. Examined under a low power, a very interesting arrangement is observed in connection with the contractile structure. A number of muscular cords are seen upon the internal surface of the heart, which are thus disposed:—they pass from two centres, which are situate about the middle of the lateral surfaces, in a radiate manner, being continuous at their extremities with the ordinary fibres; and in this way they form two stellate elevations, much resembling the muscular cords in mammalian hearts, and probably serving a similar purpose. The true auricular chamber is the sinus to which I have already alluded, but it is not contractile. The heart gives about twenty pulsations in the minute, each contraction being succeeded by a dilatation, and then an interval of repose following; during the period of rest the sector-like expansion is gradually filling and becoming convex; on the moment of the heart's dilatation, by the tendency to vacuum occasioned, it is emptied of its contents, and then, contraction ensuing, the blood is rapidly driven through the arteries. The arterial system consists in the aorta, with its branches and their numerous divisions. The aorta arises from the apex of the heart, and on attaining a length of $\frac{1}{6}$ inch it divides into two branches, measuring each $\frac{1}{24}$ inch in diameter, which continue together for a distance of $\frac{1}{4}$ inch till they reach the intestinal fold; then, both having crossed the gut, one branch becomes recurrent, and, passing beneath the intestine, runs downwards and forwards parallel with the rectum and beneath the generative organs, heart, and pericardial gland, and becomes lost in supplying the gullet and organs of the head. The posterior branch passes backwards towards the stomach, and in this course gives off about twenty branches to the intestine and liver, the intestinal branches being given away distinctly, and passing over the latter organ to their destination. These vessels divide and subdivide extensively, and form the most exquisite ramifications upon the alimentary canal, with which they contrast very markedly, being themselves of a pure white colour, whilst the intestine, from its vegetable contents, is green. Arrived at the stomach, the main artery bifurcates, one branch passing backwards to supply the ovary and caudal lobe of the liver, the second being sent to the stomach and left division of hepatic gland, upon the inferior surface of whose lobes the most beautiful arborescent ramifications may be observed. I am not disposed to coincide with the view of Erdl,* that a capillary network exists—

* 'De Helicis algiræ.' Bruxelles.

1stly. Because it is not discoverable.

2ndly. Because the rootlets of the veins terminate by apertures.

3rdly. Because the whole of the viscera in the posterior part of the body are completely unattached below to the venous integument; and as the principal arterial supply is to the inferior surfaces, had there been any intervening series of vessels, the integument and viscera would be adherent to each other in this locality. The arteries are composed of nucleated muscular fibres, having buried in them clusters of calcareous granules, which give the snow-white colour to those vessels. I cannot say I have been enabled to confirm the truth of Von Siebold's assertion, that the arterial extremities are formed of calcareous particles alone, the organic tissue being completely absent; for in every specimen I examined, where it was possible to arrive at any clear decision, I most distinctly observed, mingled with the lime-granules, long, nucleated endoplasts. The veins, as I before stated, are merely channels ploughed in the musculo-fibrous tissue of the skin, covered on their inner surface by a fold of transparent membrane; the great lateral vein of either side begins near the caudal extremity of the body, and travels forward horizontally to the lung-sac, at a distance of about $\frac{1}{2}$ inch from the median sulcus of the foot. It increases in calibre as it approaches the lung, and on its journey receives several branches from the upper and lower divisions of the integument.*

The pericardial gland or kidney, as it has been styled, is, in my opinion, no more an urine gland than is the heart or liver; nor, indeed, can I see any just reason why it has received this appellation; for I conceive the assertion of Jacobson,† that it contains uric acid, is of no weight whatever, seeing that it is based upon the idea that murexide is produced when the dried kidney has been subjected to the action of nitric acid and ammonia. Undoubtedly these reagents give rise to a reddish stain (which I fancy does not need the ammonia to its production), but it is equally true that a portion of the liver, when placed under similar conditions, will give *apparently* the same results. Moreover, the statement that this gland possesses an excretory duct is entirely without foundation, and I can only account for its origin, by supposing that in emaciated individuals the rectum has been mistaken for a duct leading to the respiratory orifice. Notwithstanding the most patient and persevering endeavours

* For the development and characters of the blood, see the admirable memoir of Mr. Wharton Jones ('Phil. Trans.,' 1846), to which nothing can be added.

† Meckel's 'Archives,' vi, p. 370, 1820.

to discover something which might be construed into a duct, I have failed signally to detect anything of the kind. This gland constitutes a sort of collar surrounding the heart, is bordered externally by the lung, and within by the semicircular canal and sector-like sinus; it is of a dark, reddish-brown colour, and measures from side to side (including heart and sinus), more than $\frac{1}{2}$ inch. It is made up of a great number of lamellæ, placed against each other like those of a fish gill, and viewed under the microscope, each of them is seen to be composed of numerous irregular vacuoles, containing within them solid, round, non-transparent, incompressible nuclei. Between the lamellæ many blood-vessels may be observed travelling from the lung to the heart-sinus, and giving off several branches, which, passing between the vacuoles, anastomose frequently. The pericardium embraces this organ and the heart in its folds, forming on the one hand, the floor of the shell-sac, and on the other the roof of the thoracic gut-chamber, and, being perfectly transparent, admits of our observing most satisfactorily the movements of the heart and sinus (fig. 5). I do not appreciate the necessity for assuming that there is any kidney in the economy of Limax; nor, if I did, should I therefore conclude, that this gland was its representative simply because one of the compounds discoverable in the urine of man, was found, or *said* to have been found, here also; for, pursuing the same line of argument, had not the kidney of man been discovered, its being known that urea is found in the sudoriparous secretion, would constitute a valid reason for asserting that *the human kidney was located in the skin.* From the descriptions of some of the earlier anatomists an immense deal of confusion has resulted, owing to the kidney being, according to one or other, termed the muciparous gland, organ of the purple, &c., and these being, in turn, confounded with portions of the reproductive apparatus.

The Nervous System is composed of four separate ganglionic masses, two superior and two inferior, which, by connecting cords, constitute three distinct rings. The first ring lies upon, the second surrounds, and the third is placed immediately beneath, the gullet, and springs, as it were, from the second. The two latter are by far the most distinct, and from the circumstances of their size and contiguity have been generally supposed to embrace the entire nervous system. The anterior ganglia are two in number, exceedingly minute, measuring about $\frac{1}{20}$ inch in length, and situate on either side of the enlarged oval organ or head, being at the superior and posterior border of this structure; they are of a dumb-bell shape, slightly curved, their concave edges embracing the convexity of the head; they are of a whitish-yellow colour, but do not contain as much calcareous matter as the ganglia of the posterior divisions; they are attached to each other by their posterior expansions, through the medium of a strong, nervous filament, $\frac{1}{4}$ inch in length. From their anterior extremities eight nerves pass off, four on each side, to supply the various portions of the gustatory and linguæ-prehensile apparatus; finally, from each posterior extreme, a minute, lingual twig is seen passing to the superior surface of the gullet, and two long internuncial branches, which take their course backwards, on the upper surface of the œsophagus, for a distance of about $\frac{3}{4}$ inch, and terminate in the second circle. This is formed of two irregular, oblong pieces (one lying on the gullet, and the other beneath it), and a connecting nerve, which passes vertically downwards on each side, and which, though *apparently* a single flattened structure, is actually composed of two riband-like nerves, from which *no* branches are given. The upper ganglion-mass is slightly concave, both anteriorly and posteriorly, but more so behind than in front; it is composed of two ganglia, which have become completely amalgamated, and which are indicated by a transparent colourless spot at each extreme. That the ganglia are not *merely contiguous*, I have satisfied myself, and, from my own repeated observations, must give unqualified denial to the assertion of Von Siebold,* *that the ganglia, though fused into one in Murex and others, are not so in Limax.* This nerve-mass is easily seen on removing the heart, intestine, and reproductive organs, and is the more readily perceived on account of its snowy whiteness, which I imagine is due to the presence in large quantity of calcareous granules, for when the structure has been for some time immersed in acetic acid the colour is lost, and the mass becomes transparent. From the translucent and crescentic ends of this supra-œsophageal mass, four pairs of nerves arise; of these, the first pair passes to the superior tentacles, supplying these organs with filaments, and transmitting a branch to the eye, which is the true optic nerve;† the second pair is also distributed after many divisions to the inferior tentacula and lips; the third pair runs downwards and forwards, and,

* See 'Vergleichenden Anatomie,' Burnet's translation, note 9, p. 235.

† Johannes Müller ('Ann. des Sci. nat.,' xxii, 1831) maintains this view also, which, so far as I can see, is the correct one. It is strange, however, that Siebold contends for the distinctness, from its origin, of the optic nerve.

after a slight degree of ramification, is lost in the tissue and muscles of the lower tentacles; the fourth and most posterior pair passes forwards, and, being lost upon the mouth and adjacent structures, deserves the name of buccal. The third ring we now arrive at. It is about as wide as the second (which measures transversely somewhat more than $\frac{1}{8}$ inch); indeed, its upper ganglionic mass is nothing more than the inferior expansion of the latter (fig. 8). Its superior component is oblong, irregular, and not very symmetrical, slightly convex anteriorly and concave behind, with its noduliform extremities pointing forwards; it is united directly by fusion to the lower mass. The latter is composed of three ganglia, soldered to each other in an arciform manner, the concavity directed upwards. The two portions of this ring are so closely related, that, to the naked eye the existence of an intervening space is barely perceptible. It is from this congeries of ganglionic centres that the different viscera and the great pedal muscles receive their nervous filaments, which, though numerous at the periphery, are referable to five primal pairs, and an azygos central branch proceeding to the posterior surface of the head. The first, passing from the superior extremities of the mass, supplies the heart, part of the gullet, stomach, and the lungs. The divisions of this pair are peculiar, for many of the threads, after separation, again unite, thus forming a very rudimentary plexus. The second, third, and fourth pairs all originate in the lateral portions of the ring, and terminate in the walls of the intestine, the reproductive organs, and the liver. The fifth pair is the most inferior, and arises from the inferior and internal border of the external walls of the ring, leaving a central and included space, from which *no* nerves start. The nerves comprised in this couple are "the great pedal;" they direct their course backward on either side of the great central *gland* (?), and beneath all the viscera, and after having transmitted three or four branches to the musculo-connective tissue of the foot, terminate at a distance of 2 inches from their origin, in that portion of the pedal organ, just beneath the ovary, and last lobe of liver.

Histology of Nervous System, and general remarks thereon.—The nerves viewed under the microscope present rather the aspect of connective tissue than the tubular appearance characteristic of vertebrate nervous fibres, the outer edge of each individual nerve seeming denser and to have undergone more decided differentiation than the inner portion. On entering the ganglion the nerve splits up into a considerable number of delicate threads, which become lost between the endoplasts of the ganglion itself. On no occasion have I been enabled to discover the division of the ganglion into compartments, as described by Von Siebold. I have carefully prepared sections with the assistance of Valentin's knife, and have subjected these slices to the action of the compressorium, and in both cases the same appearance was presented to the eye, viz., an opaque periplast, consisting of fatty matter and calcareous particles (as evidenced by transparence ensuing on immersion in a mixture of acetic acid and ether), imbedding numerous large, and readily perceivable endoplasts of the following kinds :

A. With an outer wall, granular contents, and a well-defined nucleus and nucleolus.

B. With two outer walls, the substance between the two clear and non-granular; the interior filled with a granular material, a nucleus, and two or three well-marked nucleoli (fig. 7).

Both varieties were of an irregularly elliptical outline, large and small, but *never pedunculated.* From Ehrenberg's observations on Arion, I had expected to find tailed globules in Limax, but they have no existence. Anderson's* woodcut is calculated to mislead, because he has not given the proper number of nerves arising from either the superior, or inferior ganglia, and, besides, he has fallen into error in representing two pairs of filaments as united to the bands connecting the supra- and infra-œsophageal centres; and one would suppose from his engraving, that the pharyngeal nervous masses had no direct connection with the others. It might be objected to the foregoing account, that, I have taken no cognizance of the splanchnic series as a special system; but I would reply, that on this subject I hold the opinions or M. Claude Bernard† to be in the main correct.

Sense System.—Organs of Hearing.—It is stated in most works on the anatomy of molluscs that these organs are represented by a pair of transparent, membranous saccules, containing either siliceous or calcareous particles termed otolites, and placed upon the inferior nervous masses. I frankly confess that I have never succeeded in finding them present in Limax. I have taken great pains to detect them, but in vain, and although naturally anxious to discover some

* 'Cyclopædia of Anatomy and Physiology;' Article "Nervous System;" Division "Comparative Anatomy."

† 'Med. Times and Gazette,' vol. for 1861; and 'Journ. de Physiologie.'

apparatus which I could set down to their credit, up to this time my efforts have been unsuccessful. From this circumstance I am led to suspect that in this creature no auditory mechanism really exists, and this suspicion is somewhat strengthened by the fact, that, the so-called ear-vesicles are said to be among the first detectable organs in the embryo, which I should not suppose probable as regards an appendicular mechanism or sense-capsule. To speak more plainly, if we were informed, that, in the embryonic life of a vertebrated animal, the most well-marked system was the auditory, should we not be inclined to fear there was some blunder in either the statement or the observation? And, besides, if the otolitic capsules be located upon the lower nervous centres, as is asserted, and thus virtually buried in the viscera, how are the sonorous impressions to be received from without? Surely, this would not be an advantageous arrangement of parts, nor in obedience to the simplest laws of acoustics. For the only method by which a vibration could be conducted to the receiving vesicle would be through the mouth and œsophagus, so that the familiar expression "swallow" should not be at all inapplicable.

Organ of Touch.—Some state that the tactile sense is resident in the inferior tentacula, these being, according to the same authorities, provided with bulbous enlargements similar to those of the upper ones. Respective of their function I can offer no comment, but I cannot just now endorse the opinion that nervous expansions exist here; an enlargement of *some* kind is occasionally observed, but I am not prepared to admit its nervous character. Moquin-Tandon* attributes to these tentacles the sense of smell.

Taste.—This faculty, I am disposed to *think*, resides in the rugose integument forming the lateral boundary of the mouth; this portion of the labial organs is supplied on each side with a branch of the inferior tentacular nerve, and here a peculiar and interesting nervous arrangement may be observed. The branch, on reaching the tegumentary fold alluded to, widens as it approaches its extremity, and terminates in a pectinate expansion, which is imbedded in the delicate skin of the lip; this comb-shaped structure results from the division of the final portion of the filament for about $\frac{1}{8}$ inch distance into a series of minute twigs, which pass off on either side, and become lost in the neighbouring tissue.

* 'Histoire naturelle des Mollusques terrestres et fluviatiles,' tome i.

Organ of Vision.—The eyes are two in number, and are situated, one at the extremity of each superior tentacle, and are recognisable as a pair of black spots within the membranes by which they are surrounded. By delicate manipulation the eye, together with the tentacular and optic nerve, may be separated from the surrounding darkly stained connective tissue, and then is seen the origin of the nerve of sense from the extremity of the tentacular branch. The latter, just before it terminates in the end of the tentacle, expands into five or six short, thick, and unequal divisions, thus exhibiting a palmate end, the fingers being arranged in such a position as would be assumed by those of the human hand, when grasping a large ball, and from the centre of the palm, so constituted, a very fine nervous thread travels to the eyeball, the intervening distance being exceedingly short. This attenuate nerve having reached the eye, *apparently* enters the posterior part of the sphere, but, so far as I could observe, it becomes blended with the membrane of the ball, which is a connective-tissue structure, and after the choroidal pigment has been completely removed, the two tissues, those of the optic nerve and sclerotic, appear, not only continuous, but identical in structure, and this peculiarity, although at first sight anomalous, is at once appreciable by an appeal to investigations, of my friend, Prof. Beale,* into the structure and homologies of connective tissue. Indeed, I very much doubt that any structure resembling a retina, has ever been observed in pulmonates, and this idea is borne out by the fact that, Von Siebold, in speaking of the organs of vision generally, among cephalopora, writes, "The internal surface of the choroid is covered by a whitish pellicle, which is *undoubtedly* the retina;" adding afterwards, "Kûhn affirms that he has *seen* this white pellicle in Paludina," as if he hesitated to accept the *onus probandi* himself. I confess I am sceptical as to its existence, having never observed the faintest trace of it myself. The sclerotic membrane forms a more or less spherical sac, which is quite transparent at a point opposite the apparent *penetration* of the nerve; internally this sac is lined with exceedingly fine, black, granular pigment, which, so far as I could observe, is not enclosed in cells, but is bedded in the inner wall of the sclerotic, and for the most part is disposed in regular lines, long and short alternately, which assume the horizontal position. The eyeball owes its globular form to being filled with a thick, tenacious, perfectly transparent, vitreous humour; this is very well observed by

* See 'Quart. Journ. of Micros. Science' for Oct., 1861; 'Med.-Chir. Review,' Oct., 1862; 'Archives of Medicine;' &c.

exerting compression on the sac, when, a portion of the wall being ruptured, the contained gelatinous matter is gradually forced out in a worm-like manner, or exactly as is the semi-fluid oil colour from the leaden tube of an artist. The cornea is at once perceived, and on two or three occasions I have teased from it a small, solid, transparent, pointed, elliptical body, which I dare say serves the function of crytalline lens, but I do not think this is easily or often detected. The integument is attached to the eyeball in front, but I cannot imagine it passes over it, else I should suppose there was a second cornea, unless, indeed, it were termed conjunctiva. Yet Siebold states that the integument passes over the eye-ball as a thin, transparent lamella. Siebold also asserts that in no case can ganglionic globules be seen in the expansion of the so-called optic nerve, but why, I cannot think, it being a matter of the greatest ease to discern the very well-marked elliptical endoplasts, with their nuclei and granules.

The pedal gland consists of a central canal closed behind, open in front, traversing the internal portion of the tissue of the foot, from the posterior extremity of the creature to the integument immediately beneath the mouth, and having attached to its lateral borders clusters of endoplasts, which simulate the structure of follicles. Between these clusters numerous blood-vessels lie, and therefore, did we suppose a water-vascular system to exist, we might conceive of the aqueous fluid being through this channel introduced into the blood. Various functions have been assigned to this organ, among which not the least *seemingly* absurd is that of smell, which Leidy* has set down to it.

Reproductive System.—The organs which collectively make up this system are, as we might anticipate, akin to those represented in the genus Helix. They are those of the two sexes combined ; that set which is characteristic of either sex being morphologically complete in every individual, and not, as Steenstrup† would have us believe, the non-abortive moiety of a complex apparatus, which exhibits a complete bilateral symmetry. For perspicuity, the parts comprising this machinery may be thus classified, as in the case of Helix:

1. Female.
2. Male.
3. Androgynous.
4. Appendicular.

* Silliman's 'American Journal of Science,' 1847; and 'Ann. Nat. Hist.,' xx, 1847.

† 'Untersoegelser over Hermaphroditismus Tilvaerelse i Naturen,' 1845, p. 76.

The female portion, as with Helix, comprises the ovary, oviduct, albumen-gland, uterus, and vagina. The ovary, unlike that of the snail,* is not a mere flattened expansion, almost inseparably united to the lobules of the liver; but is a thick, imperfectly egg-shaped, oblong gland, of a purplish-brown colour, divided coarsely into three or four lobes, and these again into innumerable lobules, which project in every direction, being more loosely bound together than in Helix. It is situate beneath the final and posterior lobe of the liver, and immediately behind the stomach; it is bounded below by the musculo-cutaneous structure of the foot, upon which it lies almost freely, being merely attached to the inferior portions of the liver by loose filaments of connective tissue. It is $\frac{3}{4}$ inch long, $\frac{1}{2}$ inch wide, and $\frac{1}{4}$ inch thick, but in the unimpregnated condition it is diminished in bulk by about one third of the whole. Viewed under a medium power, the lobules appear as small cavities, of an irregular, spherical shape, which seems due to compression, these being filled with a transparent fluid and numerous endoplasts containing granules; to each group of five or six lobules a slight branch of the oviduct is adherent, but it cannot be traced to any individual lobule, appearing, as it were, to become continuous with the connective tissue which serves to unite them in bundles.

In the anatomy of this organ I have been more than ever convinced of the error of H. Müller's views, for if any second vesicle existed within the ovarian lobule, I could not have failed to detect it; but nothing bearing the faintest resemblance to an included saccule could be discovered; nor have I detected the presence of zoosperms, although I have occasionally seen them in small numbers within the ovarian follicles of the snail. The ovary is provided with a tolerably large blood-vessel, one of the main branches of the superior division of the aorta, and the chief peculiarity of the circulation is this:—the arterial vessel, having sent several branches to the gland, passes from it, and is distributed to the posterior lobe of the liver. At the middle of the anterior inferior border of the egg-gland enters the oviduct, a delicate conduit, cylindrically tubular throughout, a little convoluted anteriorly, and containing *no* second canal, which is very slightly larger at its anterior than at its ovarian extremity, and is of a pearly-white colour. It is situate between ovary and uterus, being placed at first beneath the liver and stomach, but afterwards, assuming a superior position, lies

* "The Generative System of Helix aspersa," by the author. 'Quart. Journ. of Micros. Science' for Oct., 1861.

between the pro-stomach and the duodenal bend of intestine, the ovarian artery running beside it, and, finally, about the middle of the body, it becomes confluent with the posterior portion of the uterus. It measures about $2\frac{1}{4}$ inches in length, and in width $\frac{1}{30}$ inch behind and $\frac{1}{24}$ inch in front. The albumen-gland resembles that of the snail; it is, however, less compact, and more linguaform than boat-shaped, and is usually of a yellowish-white aspect both externally and within; it is continuous anteriorly with the uterus, and it is not easy to draw a decided line of demarcation between the two, the albumen-gland seeming but a solid continuation of the uterus, on which, moreover, it is folded back, (when in its normal position) and retained by almost gossamer folds of connective tissue. It lies with the uterus beneath the liver, and inferior to, and to the right of, the various folds of intestine. In the impregnated individual it attains a length of 1 inch, and a breadth of $\frac{1}{4}$ of an inch at its widest portion, for it tapers gradually in the posterior direction. Owing to the existence of several transverse divisions, it is resolved into many segments or lobules, each of which assumes a rudely indicated wedge-shape, and is adherent internally along the inferior mesial line [to a slender branchlet of the oviduct, which traverses the gland from end to end. Microscopically, the anatomy is similar to that of Helix—an enormous assemblage of albumen-globules and fibres. I have never noticed any distinction, as regards opacity, between the component lobules of this gland, but on two occasions I have found it entirely absent. The uterus may be regarded as the tubular prolongation of the albumen-gland, which has just received the termination of the egg-duct. It is a vessel of considerable calibre, and of a pure, translucently white colour; it is thrown into about a hundred transverse folds, which give it, to an extraordinary observer, the semblance of as many little pockets lying side by side on a string, and which may be due to a shortening (relatively) of one side of the tube, thus giving rise to a corrugated or plicated appearance on the other, by forcing it into a series of puckers. It is located between the white-of-egg-gland and the vagina, to which its anterior end is conjoined, and makes two or three serpentine windings in its passage from behind forwards; it is accompanied by a medium-sized artery, and has upon its (as it seems) shortened border, the testicular follicles, firmly adherent. It is placed in the purely abdominal region, and beneath the liver, gullet, and folds of the alimentary canal, lying more or less to the right side of the body, and retained *in situ* by various ligamentous filaments of connective tissue. When separated from its attachments, it is a little more than $2\frac{1}{2}$ inches in length; whilst in calibre, at its widest point, and even when undistended by ova, it reaches $\frac{1}{4}$ inch in fully developed specimens. Structurally, it possesses all the features of inelastic connective tissue, with a few nucleated fibres, which have the aspect of involuntary muscle. It is contracted anteriorly and infundibuliform, and is continued as a strong, straight, white duct, about $\frac{1}{2}$ inch long and $\frac{1}{12}$ inch wide, which I term the vagina, and this, in its turn, opens into an expansion of the cloaca, for which I would propose the name of egg-sac, and of which I shall speak presently. The male section of the generative organs includes the testis, with the vas deferens and penis, which latter are virtually one and the same organ. The sperm-forming gland is a simple and prolonged structure, being constituted of a repetition of similar parts, each of which follows the follicular type; it is commonly of a whitish-yellow colour, and from this circumstance may at once be distinguished from the uterus, which otherwise, to a careless observer, might seem to be part and parcel of it. Being strongly united to the shortened border of the uterus, it has the same relations and position as that vessel, and is of the same length, but in breadth is not more than $\frac{1}{12}$ inch at its widest part. It consists of a narrow duct—cæcal at its posterior extremity, which lies against the albumen-gland, and free in front, where it is continued as vas deferens—to one side* of which is attached a collection of follicles, which secrete the sperm, and pour their contents into the common excretory duct. Each follicle is of an ovato-lanceolate outline, the apex pointing outwards, and from its surface numerous papillary elevations rise, which I fancy are lesser follicles, thus giving to the whole gland a higher position as regards *organization* than that of Helix; indeed, it is remarkable that two animals so very closely related zoologically should exhibit such well-defined differences in the minute structure of their glandular mechanisms. Here, however, as in the snail, I observed, on compressing a portion of a follicle, very many squamose, oval endoplasts, occasionally nucleated; the testicular duct leaves the uterus as this passes into the vagina, and is now called the vas deferens. This channel, I should think, has been incorrectly designated; for although in other molluscs it is easy to trace the point of union between it and

* This affords a marked contrast with the same organ in Helix, in which a double row of follicles is found (*vide* 'Dub. Quart. Journ. of Science,' April, 1861).

the penis, yet in Limax the one is so completely the prolongation of the other, that, it is impossible to indicate either the commencement of penis or the termination of vas deferens; hence this tube may be looked on as the penis. It is of a transparently white colour, a little wider in front than behind, and takes its course from the testicle posteriorly, to the generative outlet, in the following manner. It first curves outwards and to the left, and then, turning in the opposite direction, approaches the right side of the body, passing over the uterus and beneath the rectum; here, placed in the right lateral region, and covered by the membrane of the lung, it travels anteriorly as far as the cloaca, when, bending at an acute angle, again below the rectum, it insinuates itself between the ovary and duct of the spermatheca, posterior to the latter, and, finally, after lying beneath the aorta and above the egg-sac, it opens by a rounded aperture into the cloaca. The androgynous division involves the sperm-sac and its duct. The former is a spherical expansion of the latter, with an exceedingly thin, transparent, easily ruptured coat, upon the outer surface of which several arterial twigs ramify, producing, by the contrast between their white branches and the transparent groundwork, a very beautiful appearance. I cannot think how Treviranus* could have supposed that this vesicle was a urinary organ, for it has not the slightest connection with the so-called kidney, and, on the other hand, is decidedly attached to the generative outlet by its duct. It is situate on the left of the uterus, by whose anterior fold it is embraced, has the gullet below it, and is covered by the right anterior lobe of the liver. In the unimpregnated animal it is empty, wrinkled, and triangular shaped, with a length of $\frac{5}{16}$ and a breadth of $\frac{1}{4}$ an inch; but subsequent to coition it is distended with semen (which, contrary to the assertion of Von Siebold, is not at this period fully developed), assumes the globular form, and has a diameter a little over $\frac{3}{8}$ inch. Its microscopic structure is that of connective tissue, simulating here and there a fibrillated constitution, which disappears under the influence of caustic potash, and having a few of the nucleated endoplasts of non-striated muscle. It empties its contents into the cloaca, through the duct of the spermatheca. This is a strong and short canal, uniting the sac and outlet. Starting from the former, it travels to the right beneath the aorta and uterus, and, curving across the penis, with the egg-sac to its left, it communicates with the cloaca by a circular opening, just beside the penis and at its dextral border. It is

* 'Zeitschrift für Physiologie,' i.

about $\frac{1}{4}$ inch long, and somewhat more than $\frac{1}{15}$ inch in diameter.

The appendicular series embraces the egg-sac and cloacal glands. The first is a conical, papillary extension of the hinder portion of the outlet, its apex towards the left and front, and its base in the opposite direction. Interiorly, it is hollow, and receives at its greatest diameter the orifice of the vagina, which projects into it something in the manner of "prolapsus ani." I do not know that any function has been ascribed to this cavity, and in the absence of any other office, and from the fact that, during the deposition of ova each egg remains within it for some time, I would suggest that it *may* serve to place the ovum in a position to receive the attachment of the peculiar threads which connect the deposited ova. It measures $\frac{3}{8}$ inch or thereabouts in length, and has a thickness varying between $\frac{1}{6}$ and $\frac{1}{4}$ inch, and is composed of muscular and connective bands intermingled.

The cloacal glands, so far as I am aware, have not been heretofore described, yet they are numerous and interesting, and deserve notice, because in Limax the multifid vesicles of the Helicidæ do not appear; and, therefore, it is likely that, be *their* function what it may, it is here performed by these cloacal organs. They present in their entirety to the naked eye a purplish-brown, tripy, pilose aspect, and surround closely the internal or abdominal surface of the cloaca, from its anterior extremity to the egg-sac; their ducts pierce the cloacal walls, and may be seen externally (on the inner or non-abdominal side) as a cluster of minute apertures. If a thin, carefully prepared section be made, with Valentin's knife, the following structures are observed. An immense quantity of dark follicles, lying in indifferent tissue, and recalling at first sight the Meibomian glandules of the eyelid; each follicle is compound, being composed of a central stem or channel, which, as it passes towards the outer surface, sends off three or more lateral branches, and to the end of each of these a dark, spherical, grape-like vesicle is united, which, when ruptured by compression, shows its contents to be a liquid matter containing endoplasts and granules (fig. 2). The common generative outlet I have not yet described, for as it belongs to no section in particular, it could not have been referred to till the other regions were disposed of. Divested of its glandular appendages, it is a very simple tube, about $\frac{1}{4}$ inch long, and as wide also when distended; into its posterior part open the penis and the sperm-sac-duct; it is attached to the egg-sac behind, and in front, where it forms the generative aperture—which is closed by an elastic band—

is lost in the general integument. It is upon the right side, about midway between the pulmonic orifice and right upper tentacle, and in a plane about $\frac{1}{4}$ inch lower.

The eggs of this creature are deposited during the months of August and September, usually under large stones, but seldom in the earth; they are about twenty in number, collected together by means of glutinous threads which adhere to them. The egg is spherical, of an opaque white, measures about $\frac{1}{9}$ inch in diameter, and consists of two coats, a quantity of albumen, and the yelk-mass. The outer coat, and that in which the opacity is observed, appears glistening and granular under the microscope when viewed by reflected light; when isolated, it is found to be exceedingly tough, and to be composed of some material having a fibrillated structure apparently, and bearing in its substance particles of carbonate of lime, for, when acted on by weak acetic acid, an effervescence results, and the opacity vanishes. The fibres of which it seems made up are not real, but due possibly to the wrinkling to which the membrane is exposed in submitting it to examination; at all events, when a portion of it has, by careful manipulation, been flattened out, and allowed to remain for some time in a solution of caustic potash, the fibrillation disappears, and a clear, structureless membrane remains. The inner coat is transparent, but presents the falsely fibred aspect of the outer one. The yelk is a yellowish mass, presenting the usual granular aspect, and built up of rounded endoplasts oil-globules, and coloured granules.

General remarks.—In contrasting the reproductive apparatus of Limax with that of Helix, as concerns position, form, and structure, we find that, while occupying the same place as that of Helix with relation to the viscera among which it lies, it presents many characters, morphologically and histologically, which were not observed in that of the latter genus. We miss here the dart-sac, multifid vesicles, flagellum, and spermatheca-cæcum, which are so fully developed in Helix. The first has no representative; the cloacal glands may be a substitute for the second; and since it is probable that the third and fourth are mutual adaptations—the one owing its development to the requirements of the other—it follows that the non-development of the one is consequent upon the teleological absence of the other. Here, too we observe no cloacal valves, and from this it is probable that the function which in a former memoir I attributed to these organs is not the incorrect one. It is not a little surprising that Moquin-Tandon, who has given a rude engraving of a portion of the reproductive apparatus, should have overlooked the glandular character of the outlet, and not less so that he should have represented the egg-sac as being of acrescentic form, and termed it the "horned appendage." Moreover, I can with difficulty imagine that he has ever seen the spermatic particles, for he figures these latter (as though he had been looking at tadpoles or, more probably, at pictures of human semen), with gigantic spherical heads, whereas, actually, they only exhibit an approach, and a very faint one, to a capital extremity, in the form of a little spiral coil. The testicular and uterine divisions of the genital system are supplied with blood by a lateral vessel, which passes from the vaginal end to the albumen-gland, lying upon the border of the uterus, and transmitting branches to this structure and to the testis. With regard to the distinctness of the latter organ, I may state that its excretory duct is not the semi-canal which Prevost* took it for; I have, after a little manipulation, succeeded in isolating completely its lower or anterior end, together with its continuation, the penis. The retractor muscle of the intromittent tube is often absent, but when present is a simple band, arising from the integument above the foot.

It is almost impossible to describe the anatomical peculiarities of a creature so highly organized as that of Limax, with the accuracy, and perspicuity which are desirable; hence, doubtless, in the foregoing *very general* account there may, of course, be errors, not only in observation, but in induction. These—should they exist—it is hoped, may soon be pointed out, by others more skilled in the examination of molluscan organisms than the author, who can only add, in conclusion, that his *sole object* in the communication of these researches, has been the advancement of biologic science, by an effort to elucidate what seemed to him, a subject left too long in obscurity.

* 'Ann. des Sciences nat.,' xxx.

Note *on* Dr. Wallich's Microscopic "Jaw." By G. Busk, F.R.S.

In the October number of the 'Annals of Natural History' (p. 304) is described and figured an organism contained in a muddy deposit dredged up at St. Helena, and regarded at that time by its discoverer, Dr. Wallich, as the lower jaw of a vertebrate animal, although, as he confesses, he had not then submitted it to any detailed examination.

The minute size, however, and general characters of the specimen, when it was exhibited at the meeting of the British Association at Cambridge, led many at once to doubt the propriety of this determination. Opinions, nevertheless, appear to have been very widely divided as to the real nature of the object. In a subsequent notice respecting it, in the December number of the same journal (p. 441), Dr. Wallich, in retracting his former opinion, as having been too hastily formed, states that the specimen had been pronounced by different observers to be—the mandible of a fish—a portion of the lingual ribbon of a *Mitra*—the claw of a minute crustacean—part of the manducatory apparatus of *Notommata* or an allied species,—and lastly, a valve of the pedicellaria of some species of Echinus, in which last view he is himself now inclined to agree.

As it would appear, therefore, that there must be something peculiar in a structure about which such diversity of views can be entertained; and as Dr. Wallich, in his latter communication, has cited me as the author of the last opinion in the above list, it may perhaps be interesting to some, that the grounds upon which it is formed should be stated.

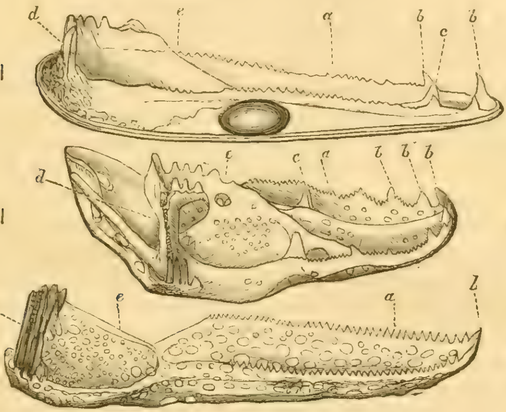
As none of the drawings hitherto given of the organism afford anything like a correct notion of its real appearance, I have had the accompanying figures prepared by an artist, wholly, I believe, unaware of the nature of the disputes about it, and whose representation, therefore, may be regarded as uninfluenced by any preconceived opinion.

Of the various opposed views above enumerated, it appears to me, and will perhaps also appear to most others, that the only ones requiring serious consideration are that advocated by myself and that so ingeniously supported by Mr. C. Spence Bate, in the December number of the 'Annals of Natural History' (p. 440). That gentleman, whose opinion in such a matter, if he had had an opportunity of inspecting the specimen itself, would, of course, carry the very greatest weight, suggests that the so-termed "jaw" may be the *dactylos*, or moveable claw of a minute crustacean (*Phrosina*). But, with all due allowance for the circumstance that this

FIG. I ×240

FIG. II ×120

FIG. III ×210



opinion appears to have been based only upon the inspection of the original very faulty figure given by Dr. Wallich, it seems to me that, even with this allowance, an insuperable objection to Mr. Spence Bate's view would arise from the fact that the "second row of marginal armature" is really placed as if it were the second ramus of an actual jaw, and not, as he erroneously interprets or appears to interpret the figure ('Ann Nat. Hist.,' x, p. 304), in the same line or plane, but above the first row, as I understand him to mean.

There can be no doubt, as he or any one would see on a glance at the specimen itself, that the two serrated margins are placed one behind the other, as the alveolar borders of a jaw would be. This being the case, it is needless, I should fancy, any longer to entertain the question of the object being the claw of a crustacean, in which the serrations or denticles, if there be any, are always placed in a single median row.

But having negatived this view, upon what grounds is the thing to be regarded as the valve of a pedicellaria? This may be explained in a few words, and will, I hope, be found to be satisfactorily elucidated by the adjoined figures. Of these, fig. 1 represents the "jaw" as it is exhibited in Dr. Wallich's preparation, in which the object is unfortunately a good deal obscured by foreign matter. Fig. 2 is the side view of a valve of the pedicellaria of *Echinus lividus*, of which some mounted specimens have been kindly furnished by Dr. Wallich, whilst fig. 3 shows the corresponding part of the pedicellaria of a species of *Amphidotus*, as I am informed by Mr. R. Beck, to whom I am indebted for the illustration. The figures of several other pedicellarian valves might have been added, all differing more or less *inter se*, though agreeing in essential structure; but I have thought the above examples would be sufficient for the present purpose. I would remark, however, in passing, that a full account and accurate figures of the varieties which exist in the pedicellariæ of various Echinidæ and Asteridæ, would afford a subject for a very useful and interesting paper, and might assist, perhaps, very considerably, in the discrimination of species or genera in those families.

In those cases that I have examined, and probably in all, the pedicellariæ of the *Echinidæ* consist of three valves, articulated apparently in a complex manner to each other, and furnished with appropriate processes for the attachment of the muscles by which they are moved. It is not my intention, nor, in fact, in my power, to describe fully the mechanism of these organs, but simply here to point out in a few words the essential points regarding them, so far as they throw light upon the structure of the "jaw."

Each valve consists of a spoon-shaped distal portion, at the base of which is a strong, curved, arched process, like a door-knocker, and on either side of the same part an irregular process or condyle, by which the valve appears to be connected by a ligamentous tissue with those next to it. Viewed on the inner or concave side, the valve will be seen to be strengthened by a prominent median ridge or kelson, from which a ridge passes off obliquely forward on each side, nearly to the edge of the spoon-shaped portion. This kelson posteriorly or towards the base of the valve, rises into a strong, bluntly-toothed process, generally, I believe, connected to the sides of the base, or to the external condyles above mentioned, by a slender calcareous arch. To this rough eminence of the kelson I conceive the occlusor muscles or muscle to be attached, whilst the dilators are doubtless inserted in the door-knocker appendage below. The anterior part of the kelson sometimes also supports one or more sharp denticles,* but in some cases, as for instance, I think, in *Echinus sphæra*,

* I had entirely overlooked the median tooth in the "jaw," and was quite unaware of the occurrence of any in that situation, in other Pedicellariæ, until it was pointed out to me by my friend Mr. R. Beck, to whose quick sight and ready assistance I am much indebted on the present as I have been on other occasions.

this median armature is wanting in the "spoon," whose edges also in that species are armed, not with sharp denticles as in all other instances I have as yet seen, but with blunter transverse ridges—presenting, in fact, pretty nearly the same difference that exists between the dentition of *Mustelus lævis*, and that of other dog-fish. The only other essential point to which I need refer, is the serration or dentition, as it might well be termed, on the edges of the valve. This armature usually consists of a series of very fine teeth, extending from the hinder end of the border throughout its whole length, except at the point where it may be interrupted, as appears usually to be the case, by one or more considerably larger denticles on each side, or at the apex. Besides this, the margin may be either straight, as in *Amphidotus* and *Echinus sphæra* and the "jaw," or scalloped as in *Echinus lividus*. And doubtless numerous other variations will be met with.

Now, upon inspection of the figures, it will be seen that all these parts, except the hinder door-knocker process, which is wanting in every specimen, being easily detached from the rest of the valve, are exhibited in the "jaw." The letters in each figure are applied to the corresponding parts.

a. The serrated margin.
b. The larger denticles.
c. The median ridge or kelson, with a large denticle in front.
d. The lateral condyles.

On the Nerve-Cells *of the* Spinal Cord *in the* Ox.

By W. Hendry, Surgeon (Hull).

The careful and patient manipulation required in order to display and mount the *nerve-cells* of the cord has undoubtedly tended to retard any general knowledge of these most singular and interesting bodies, whose structure and relations have hitherto remained in comparative obscurity. They are numerous and well-defined corpuscles, exceedingly variable in size and form, and furnished with conspicuous circular nuclei and nucleoli, of a yellowish colour, and usually presenting towards one or other extremity a pigmentary matter of a peculiar kind. They are also furnished with one or more processes, and hence have been designated, *unipolar, bipolar,* or multipolar cells. The processes in question are described as anastomosing filaments, or as branches connecting one cell with another, or as continuous with the peripheral nerve-fibres. In some cases, again, they appear to have free terminations in the surrounding tissues. But these are questions upon which all observers are not satisfactorily agreed; nor is this a matter of surprise when we consider the extremely minute portions subjected to microscopical examination, the necessary preliminary preparation required, and the unavoidable disturbance of parts, all tending to interfere with if not wholly to destroy the normal arrangement of such delicate structures. Nevertheless, keen research, multiplied observations, and careful description of what is seen, may eventually lead to a more perfect knowledge of the distribution of those parts wherein at present some ambiguity may exist.

It is no easy matter, under most circumstances, correctly to determine the question of the attachments of the processes just referred to, some lying above and others below the cells, whilst others, again, abruptly terminate short of, or apparently extend beyond them; some of these appearances seeming to be produced by the rough usage employed to bring the objects properly into view. And in many instances in which we might feel inclined to believe in the union or continuity of the processes with nerve-filaments, or with other processes of the same kind, the employment of higher magnifying powers ($\frac{1}{4}$ inch) will in some cases resolve these connecting filaments into capillaries, which are so distributed and so completely encircle the cells, that but for the characteristic nuclei in the walls of the capillary vessels, very incorrect inferences might be entertained as to their true nature. From careful and repeated observation, however, my own conviction is, that anastomoses do exist between one cell and another, and that the processes do likewise become connected or continuous with nerve-fibres, and that free terminations are also to be met with, although it is not improbable that the latter may be produced in consequence of the manipulation to which the parts are subjected.

The nucleated vessels I have observed in the spinal cord of the ox, in close apposition with the nerve-cells, have a diameter of $\frac{1}{1300}$th, $\frac{1}{2700}$th, and $\frac{1}{4000}$th of an inch, whilst the nuclei in their walls are about $\frac{1}{2700}'''$ in length, and are of a roundish or oval shape, with a breadth of $\frac{1}{4000}'''$, or equal in some cases to that of the vessel itself. Vessels undoubtedly exist below and above these measurements, but the extremes are not now sought for. The nerve-filaments present a more homogeneous structure, and, as a further distinction, the blood-vessels may frequently be traced in connection with others containing altered blood-corpuscles, their nature being thus placed beyond all doubt.

My present object is not so much to enter fully into the histology of the cord as to endeavour to awaken new interest in the subject, and to offer certain suggestions with respect to manipulation, by which the investigation may be rendered more easy and satisfactory.

I would, in the first place, recommend the experimenter to obtain a foot or two in length of the cord of the ox, to cut this up into pieces two or three inches long, and then to place these in a wide-mouthed quart stoppered bottle containing a solution of chromic acid, of a moderate yellow colour. Other portions may be preserved in spirits of wine. After a few days the investigation may be commenced, it being by no means necessary to wait for some months, as is usually stated to be requisite, before sections can be made. These should be made with a sharp razor, with which the larger portions are to be cut into lengths of about $\frac{1}{4}$ inch. On the surfaces thus exposed, the arrangement of parts in the interior of the cord will be seen. Its substance consists of a white external and a gray or cineritious internal substance, disposed in the form of two crescentic masses, one on either side and placed back to back, united by a transverse band or commissure. Of the horns, or cornua as they are termed, of each crescent, the anterior are short and thick, whilst the posterior are longer, slenderer, and more divergent. Besides this, the cord will now be seen to be partially divided into two halves by an anterior and posterior median fissure, the former not so deep but wider than the latter, and both occupied by a vascular membrane or tissue.

It will be found convenient to have the following articles and reagents at hand, and in readiness for immediate use.

One or two pair of surgeon's forceps, several common sewing needles, a razor, several glass slides, box of round, thin, glass covers, three or four watch-glasses, one or two wine-glasses, two or three glass rods, blotting-paper in slips of one inch square, one or two cloths, basin of water for cleaning slides, &c., lancet or two, and a pair of sharp scissors—also—

1. A solution of moderately dilute caustic soda, in a watch-glass.
2. Dilute acetic acid, in a wine-glass.
3. Water, in a wine-glass.
4. Creosote and naphtha solution, in watch-glass.

5. Microscope, with one inch objective in focus, and illuminated to examine progress.

Then take up one of the smaller sections of the cord, and with a pair of forceps lay hold of a small portion in or about the transverse commissure, or in one of the cornua, as being the parts which promise the most successful yield. This fragment may then be immersed for a few moments in the solution of caustic soda, and then transferred to the acetic acid, to neutralize the soda, and render the tissue somewhat clearer. After a minute or two transfer it to the vessel of water to remove the acid, &c., and then place it in the creosote or preservative solution. All this is but the work of a few minutes, and with a careful avoidance of a too prolonged destructive immersion in the soda-solution, a number of a similar small particles of the cineritious substance may thus be passed through the successive stages, before they are placed in the preservative solution preparatory to microscopical examination.

Any of the little portions so prepared may now be taken up with the forceps, and placed upon a glass slide, and broken up in more minute particles (size of pins' heads), which are again to be teased-out with needles as finely as possible, aided by a drop of the solution. These particles should then be so arranged that, upon moderate pressure, they shall not run together, it being desirable that they should be mounted and examined separately. The fluid may now be withdrawn by blotting-paper, and the remainder of the slide wiped dry; a drop of the solution is then to be placed in the middle, and the thin glass cover, previously breathed upon, applied by means of the forceps, all air-bubbles being carefully excluded. Moderate pressure is applied with the points of the forceps, and the surplus fluid absorbed at the edges; the slide being every now and then placed under the microscope to examine progress, until the appearances are rendered as distinct as they can be. The cover is now, probably, slightly adherent, and a due supply of solution being inclosed, the whole is to be cleansed and dried without disturbing the object, and, at the end of a few minutes, the slide may be tranferred to the turning-plate, and finished off with a border of varnish.

I have various slides in my possession prepared in this manner, which have kept for several weeks. Their ultimate durability I know not, but the measures adopted have served for my own investigations, as well as for the exhibition to others of a class of objects, which I should conceive to be thus as readily and perfectly illustrated as by any other proceeding hitherto promulgated.

Measurement of the cells.—The utmost variety exists in the magnitude and form of these bodies; they are usually described as globular in man, and Carpenter assigns them a diameter of from $\frac{1}{1250}$th to $\frac{1}{300}$th of an inch.

Kölliker gives a diameter of from ·05''' to ·06''' for the larger variety, which, being reduced to fractional parts of the English inch, shows a range of from $\frac{1}{370}$th to $\frac{1}{187}$th of an inch. My own measures of the cells in the ox, which, though for the most part are of a peculiar elongated form, are some of them more globular, average—

In length, from $\frac{1}{200}$th to $\frac{1}{130}$th of an inch.
In breadth ,, $\frac{1}{460}$th ,, $\frac{1}{300}$th ,,
Nucleus ,, $\frac{1}{2000}$th ,, $\frac{1}{1000}$th ,,
Nucleolus ,, $\frac{1}{5000}$th ,, $\frac{1}{3000}$th ,,

Kölliker gives to the nucleus in man a diameter of 0·0015''' to ·008''', or from $\frac{1}{2252}$ to $\frac{1}{1407}$th of an English inch, and to the nucleolus one of 0·0005''' to ·003''', or $\frac{1}{6000}$th to $\frac{1}{3479}$th of an English inch.

In $\frac{1}{10}$th of an inch square, or the $\frac{1}{100}$th part of a square inch, I have counted forty-nine large, elongated cells; whence it may be estimated that there are between three and four hundred thousand nerve-cells in a cubic inch of the cineritious substance in the spinal cord of the ox. How vast, therefore, must be their number computed throughout the entire length of the cord; how complex their relations, and how marvellous their functions, whether we regard them as active centres of growth and reparation, or the source themselves of nervous power.

OBSERVATIONS *on* BRITISH ZOOPHYTES. By T. STRETHILL WRIGHT, M.D., F.R.C.P. Edin.

1. On Reproduction in *Æquorea vitrina*. Communicated to the Royal Physical Society of Edinburgh, November 27th, 1861. (Pl. IV).

IN vol. i of Agassiz's 'Natural History of the United States' the following passage occurs:—"As to the Æquoreadæ, I have no doubt that they are genuine Hydroids, though I have not been able to trace with certainty the origin of the

Æquorea of our coast to any true hydroid. But the structure of Æquorea in its adult Medusa state is so strictly homologous to that of all the naked-eyed Medusæ, that even if it were ascertained that it undergoes a direct metamorphosis from the egg to the perfect Medusa, I would not hesitate to consider it as a member of the order of Hydroids, since it has simple, radiating, aquiferous tubes, a circular canal, and marginal tentacles closely connected with it, and provided with minute pigment-spots at the base." Agassiz was doubtless correct, and he might also have predicted that it belonged to the genus Campanularia or Laomedea, as it corresponded with the Medusoids of those genera in the presence of otoliths, while the Medusoids of the Tubularian hydroids hitherto observed, are destitute of those appendages. In the beginning of this month (November) Mr. Fulton sent me two living specimens of *Æquorea vitrina* (Pl. IV), one about three inches in diameter, the other about six inches and a half. The number of lips of the latter was about forty, the radiating canals, each having a long, double ovisac, about eighty, and the marginal tentacles, by estimation, four hundred. On examining the ovaries, I found that the eggs were hatched, and the young, in the form of almost invisible planulæ, were issuing from the ovisacs. These were gently extracted with a glass syringe, an instrument so useful to those who practise the obstetric art amongst the Hydroidæ, and were placed about three weeks ago in glass tanks of clean sea-water prepared for their reception. Many thousands of larvæ were placed in the tanks, and of those about a score have been developed into Campanularian polyps; about a hundred are still progressing to that end, and the rest have disappeared. It was with no little impatience and anxiety that I saw the planula during a fortnight fix itself to the glass, spread itself out into a short thread, secrete its scleroderm, put forth its polyp-bud—this last slowly swelling day by day, until at last it opened, and a polyp appeared, furnished with twelve alternating tentacles, joined together for about one third of their length by a web, the polyp enclosed in a cell terminating in many acuminate segments. It is now about six years ago that I was watching, in like manner, the slow evolution of a bud from a Campanularian zoophyte, the *Laomedea acuminata* of Alder, the bud opened, and a bright-green Medusoid issued forth, having four lips and two tentacles.* The hydroid phase of *Æquorea vitrina* is, as far as I can determine, identical with that of *L. acuminata* in shape; but is so excessively small—quite

* 'Edin. New Phil. Mag,' vol. vii, N. S., p. 110.

invisible to the naked eye—that we must wait for further development before we can determine their identity. Gegenbaur has proved that the Medusoid of Velella acquires a further number of canals and tentacles; and I have elsewhere recorded the successive changes which occur in the Medusoids of several species of Atractylis. It is also certain that such increase in the number of elements (canals, lips, tentacles, and otoliths) does occur in *Æquorea vitrina*, for the smaller specimens have always a less number than the larger. Meantime the question as to the larval state of *Æquorea vitrina* is settled. This, the largest of all the naked-eyed Medusas, is the reproductive phase of one of the smallest of all the Hydroidæ.

2. Reproduction of *Atractylis arenosa*, Alder. (Pl. IV). Communicated to the Royal Physical Society of Edinburgh, February 26th, 1862.

This zoophyte was described by Mr. Alder at the last meeting of this society. In September last I found a large female specimen at Largo, and was fortunate enough to have an opportunity of studying its anatomy and reproduction. The polyp-stems are, as Mr. Alder has shown, funnel-shaped and expanding at the top. From them the milk-white polyps issue, each furnished with an alternating row of long tentacles. The scleroderm, or corallum, is covered by a thick layer of colletoderm, which is continued over the body of the polyp, and which, when the polyp retires within its tube, fills up the top of the tube by its cushiony folds, so that the polyp is completely hidden, and the funnel appears, as it were, closed by a valve. The colletoderm in my specimen was coated and impregnated with mud. Mr. Alder's specimen was covered with grains of fine sand. I was at first inclined to believe that this zoophyte was merely a variety of *Atractylis repens*, which, with its Medusoids, I have already described to the society; but after it had been in captivity a few days, I found that it was beginning to put forth ovisacs, one on opposite sides of the polyp-stems (Pl. IV, fig. 7).

The mode of reproduction in this zoophyte is unique amongst the Tubulariadæ, though I have noticed and described it in the Sertularias and Campanularias.

The female generative sac of *Atractylis arenosa* resembles that of Hydractinia; it is a simple sac, formed of ectoderm, or the outer layer of the cœnosarc, enclosing a similar sac of endoderm, the "placenta," the whole being covered by a layer of scleroderm and colletoderm. Between the placenta and the ectoderm a large number of ova are developed, each showing a germinal vesicle and spot (fig. 8). When the ova are sufficiently advanced for extrusion from the generative cavity, the investments of the sac are ruptured, the sac assumes a long, cylindrical form (fig. 9), and a most laborious process of parturition commences. With each *pain* the ectoderm of the sac contracts laterally, like the bell of a Medusa, and at the same time the placenta (fig. 9 *c*) is dilated by fluid pumped into it from the somatic cavity of the zoophyte, so that the ova, which are floating in a milky fluid, are forced against the summit of the generative sac. Meanwhile, another process has been going on—the external surface of the summit of the sac has been secreting a thick cap of gelatinous colline (fig. 9 *d*), which is to form a *nidus* for the further development of the ova. The contractions become still more violent, until the ova are confined in a mass at the dilated upper part of the sac; this last is ruptured, and they are then forced into the gelatinous cap, which still remains attached to the summit of the empty generative sac (fig. 10 *d*). The ova now undergo imperfect fissure, and are developed into planulæ within their nest, from which they at last escape, and, after swimming in the water, doubtless become fixed and converted into polyps.

Atractylis arenosa, although it gives off an immense number of young, is one of the rarest zoophytes on our coast, probably on account of the low viability of its planulæ. While *Sertularia pumila*, one of the commonest species, the young of which are likewise developed in a similar gelatinous nest, will quickly line the vessel in which it is kept with forests of young zoophytes, not a single planula of *Atractylis arenosa*, of the immense number that were given off by my specimen, ever attained the polyp stage.

We have in this zoophyte the reappearance amongst the Tubulariadæ of a mode of gelatinous nidification which obtains in various orders of the animal kingdom—in the Protozoa, the Mollusca, the Annelidæ, the Insecta, and even amongst the Vertebrata, as in the common frog. We may ask, how is it that the ova of Hydractinia and Coryne are discharged into the water to float about without any protection, while those of *Atractylis arenosa*, the *Sertularias* and *Laomedeas*, require such various provisions for their further development? But we do not find anything in the physiology of these zoophytes to answer the question.

3. *Atractylis miniata*, T. S. W. (New species.) Communicated to the Roy. Phys. Soc., February 26th, 1862.

Polypary yellow, dendritic, branches given off at an acute angle from the stem, crooked, wrinkled, but not ringed. Polyp with eight alternate tentacles, buccal cavity silvery, endodermal lining of stomach bright red-lead coloured. Reproduction not observed.

This zoophyte was found on stones at Largo, in little gnarled, shrubby trees, about an inch high, exposed at the lowest tides. The bright-yellow colour of the polypary at once strikes the eye, which is also arrested by the gaudy colour of the minute polyps. These appear to be marked by two broad internal patches; one, corresponding to the buccal cavity, of a dense silvery white; the other to the cavity of the stomach, of a brilliant reddish orange. I have also found very minute specimens of this species at Granton.

4. *Laomedea decipiens*, T. S. W. (New species.) Communicated to the Roy. Phys. Soc., February 26th, 1862.

Polypary minute; stem filiform flexuose, with from one to five branches, each bearing a cell; the stem is annulated with about five rings above the origin of each branch; the branches are annulated throughout; cells widening rapidly towards the top, with even, double rims. Polyp with about sixteen tentacles and trumpet-shaped proboscis.

This pretty little Laomedea resembles much the *Laomedea neglecta* of Alder, except that the margin of the cell is even, and has the appearance of being double for about half its length from the rim, though, from the extreme delicacy of the cell, this character is only made out with difficulty. The reproduction of this zoophyte resembles exactly that I have described in *Laomedea lacerata*,* except that each gelatinous nest of *A. decipiens* contains only three ova, while that of *L. lacerata* contains six or eight.

5. *Clava nodosa*, T. S. W. (New species.) Communicated to the Roy. Phys. Soc., March 26th, 1862.

"Polypary creeping. Scleroderm membranous. Polyps single, small, aurora-coloured, each springing from small knot of convoluted tubes."

This zoophyte was found on the fronds of *Delesseria sanguinea* at Queensferry and Largo. The very delicate threads of the polypary creep over the fronds of the seaweed, and at intervals twine themselves into a convoluted knot of membranous tubes, from which a single polyp arises. This species occurs only at low-tide mark,

* 'Edin. New Phil. Mag.,' N. S., vol. ix.

while *C. repens,* for which it may be mistaken, is found in shallow rock-pools.

6. *Acharadria larynx,* T. S. W. (New genus and species. Pl. V, figs. 7, 8.) Communicated to the Roy. Phys. Soc., March 26th, 1862.

"Polypary branched, spirally twisted. Polyps pale orange, with two rows of tentacles. The lower row from 4 to 12, the upper row from 2 to 8 capitate."

On stones carrying *Caryophyllia Smithii,* received from Ilfracombe. This little Tubularian was about a quarter of an inch high, with three polyps, and resembled in habit *Tubularia larynx.* It bears the same relation to Vorticlava that *Tubularia larynx* does to *Corymorpha.*

7. *Vorticlava Proteus,* T. S. W. (New species. Pl. V.) Communicated to the Roy. Phys. Soc., May 7th, 1862.

Scleroderm absent. Colletoderm covering body of polyp. Upper row of tentacles capitate 5; lower row 9.

Several specimens of this zoophyte were found in the "Fluke Hole," Firth of Forth. The body of the polyp is exceedingly extensible. At one time a mere button attached to the stone on which it dwells; at another it transforms itself into the various shapes shown in the accompanying figures. A hard covering to the body would necessarily prevent or impede these motions. The scleroderm, therefore, is absent, and the whole body of the polyp is covered with a layer of transparent "colline," which extends from the foot, where it forms a thick mass, to a ridge which runs beneath the insertion of the lower rim of tentacles. The zoophyte has the power of changing its place.

8. *Trichydra pudica,* T. S. W. (Pl. VI.) Communicated to the Roy. Phys. Soc., May 7th, 1862.

This Hydroid, which I have already described to the Society,* was found recently covering a small shell from the "Fluke Hole." As its mode of reproduction had never been observed, I placed it in a small vessel of carefully examined sea-water, and exposed it to light, a mode of treatment which often induces the Hydroidæ to assume their Medusoid phase. After some time, two small Medusoids were found in the water, but I was unable, by the most careful examination, to detect their mode of development, as no "gonophores" appeared on any part of the cœnosarc. The connection of these Medusoids with Trichydra is yet open to doubt, although I

* 'Edin. New Phil. Mag.,' N. S. vol. vi, p. 108.

am convinced that no other zoophyte occurred on the shell, or in the water in which it was placed.

Medusoid of Trichydra pudica?—*Umbrella* mitre-shaped, covered with minute thread-cells. *Sub-umbrella* with four lateral canals, destitute of ovaries or sperm-sacs. *Peduncle* short, cylindrical, four cleft at the mouth. *Tentacles* four, short, with two or four intervening tubercles. *Oolites* absent. *Eye-specks* absent.

9. *On the Development of Pycnogon-Larvæ within the Polyps of* Hydractinia echinata. Communicated to the Roy. Phys. Soc., May 7th, 1862.

In a communication made by Professor Allman to the British Association in 1859, entitled, 'On a remarkable form of Parasitism among the *Pycnogonidæ*,' the author described the occurrence of certain vesicles on the branches of the *Coryne eximia*, which, although possessing a strong resemblance to the reproductive sacs of the zoophyte, and formed of all the proper tissues of the cœnosarc and its coverings, were distinguished from those organs by each enclosing a single living Pycnogon, which, in the smaller vesicles, was embryonic, while in the larger it presented an advanced stage of development. A similar observation was made by Mr. G. Hodge ('Ann. and Mag. N. Hist.,' ser. 3, vol. ix), who considered that the sacs were modified or stunted branches of the Coryne, the development of which had been arrested by the presence of the enclosed Pycnogon. On reading the papers of these gentlemen I remembered that I had, some time before, been much puzzled by the discovery of armless Pycnogons resembling Mr. Hodge's figure (pl. iv, fig. 10, *op. cit.*) in several altered polyps of a specimen of Hydractinia. In this case two or three were found in each polyp, which had assumed the form of a dilated and transparent sac, crowned by its usual tentacles. The polyps appeared to be bloated and overgrown under the use of their Pycnogon diet. Mr. Hodge's paper at once set me on the look-out for another specimen of Hydractinia tenanted by Pycnogons, and this I at last obtained by the kindness of my friend, Dr. Wilson, Demonstrator of Anatomy at the University of Edinburgh. In this, one of the polyps contained three larvæ of a pale-yellow colour, which appeared, as far as could be seen without injuring the polyp, to be destitute of legs. When first observed, the polyp was furnished with its proper complement of tentacles; but as the development of the Pycnogons proceeded, the tentacles were absorbed, and the polyp became a long sac, pointed at its upper extremity, and fitting closely on the larvæ, which appeared to be imbedded in the longitudinal folds of the highly developed endoderm. Mr. Hodge supposes that the larvæ, at a very early stage, are swallowed by ordinary alimentary polyps of the Coryne, and carried through the tubes of the cœnosarc until they arrive at a part which is about to become a polyp, which thereupon has its destination altered. And I think there can be little doubt that his surmise is correct, as in Coryne the Pycnogon sacs, in all stages of development, are not only destitute of tentacles, but are, according to Professor Allman, covered by a layer of the chitinous polypary or scleroderm. Such a mode of *nidification*, however, could not take place in Hydractinia, the cœnosarcal tubes of which are of exceedingly small calibre. Accordingly we find that the Pycnogon sacs in this zoophyte are formed, not by the arrest or change in development of an immature polyp, but by the degeneration of a tentacled polyp previously perfect.

Perhaps I ought to mention here that globular sacs are occasionally found in place of the polyps in *Coryne glandulosa*, Dalyell. These are destitute of scleroderm, and lined with a very dense brown endoderm, arranged in somewhat reticulated folds. As far as I observed, they were empty, and, by constantly undergoing alternate processes of dilatation and contraction, appeared to influence the circulation of the zoophyte. It is possible that minute Pycnogons may have existed in these sacs.

On the Urticating Filaments *of the* Eolidæ.

By T. Strethill Wright, M.D.

In the second volume, new series, of this Journal, p. 274, is contained a translation of a paper, by Dr. Bergh, "On the existence of Urticating Filaments in the Mollusca." As neither Dr. Bergh nor his translators appear to be aware that anything has been written on these bodies in Great Britain since the observations of Messrs. Hancock and Embleton were published, I am induced to lay before the readers of this Journal an abstract of a paper read by me to the Royal Physical Society of Edinburgh, on the 22nd of December, 1858, and published in their 'Proceedings,' containing observations "On the Cnidæ or Thread-cells of the Eolidæ," which I have since confirmed by repeated experiments.

"Dr. Strethill Wright, after describing the anatomy of the respiratory, digestive, and hepatic organs in the Eolidæ, stated that in his memoir on *Hydractinia echinata*, read before the society, November 26th, 1856, he had written—Hydractinia is infested by a small species of Eolis (*Eolis nana*), which peels off the polypary with its rasp-like tongue, and devours it—possessed, I suppose, of some potent magic, which renders all the formidable armament of its prey of no avail. Now, each of the dorsal papillæ of the Eolidæ contains at its extremity a small ovate vesicle, communicating, through the biliary sac, with the digestive system, and opening externally by a minute aperture at the end of the papillæ. This vesicle is found crowded with compact masses of thread-cells, which masses in *Eolis nana*, consist of aggregations of small and large thread-cells, identical in size and shape with those of Hydractinia—on which this Eolis preys—not contained in capsules, but cemented together by mucus. When we consider that each of the vesicles is in indirect communication with the stomach, I think we may, without presumption, suggest that the masses of thread-cells found in *Eolis nana* are *quasi* fæcal collections of the thread-cells of Hydractinia, which, protected by their strong coats, have escaped the digestive process. In corroboration of this view, I may mention that the *Eolis papillosa*, as figured in the work of Alder and Hancock, have a perfect resemblance to those found in the Actinias, which last animals furnish an Abyssinian repast to these carnivorous mollusca." Dr. Wright afterwards found that, as to the above idea, he had been anticipated by his friend, Mr. Gosse, who, in his 'Tenby,' after noticing the existence of the thread-cells in the papillæ, remarked—"The inquiry I suggest would be, how far the presence of thread-cells might be connected with the diet of the mollusc? And whether, seeing the forms of the missile threads vary in different genera of zoophytes, the forms of the corresponding organs in the papillæ of the Eolides would vary if the latter were fed exclusively first on one and then on another genus of the former." He afterwards found that Mr. Huxley had also doubted, previously to Mr. Gosse and himself, whether the thread-cells of the Eolidæ were not adventitious. Here were three independent observers to whom the idea had suggested itself: Mr. Huxley had first hinted it; Mr. Gosse suggested it and how it might be found to be true; Dr. Strethill Wright also had suggested it, and given two instances in corroboration of his opinion, and then he proceeded to detail observations which would, he hoped, entitle it to be enrolled as a proved fact in the records of science. 1st. A specimen of *Eolis nana* was brought home from Morison's Haven, on a shell covered with Hydractinia, taken from a rock-pool, in which was a profuse growth of *Campanularia Johnstoni*. The papillæ of this Eolis contained the two kinds of thread-cells which are found on Hydractinia, together with the large thread-cells which occur within the reproductive capsules of *C. Johnstoni*. 2nd. An *Eolis coronata* was taken at Queensferry, on a massive specimen of *Coryne eximia*, which was very abundant there. The thread-cells of *C. eximia* were very distinctive, being very large, oval, and containing a four-barbed dart. The thread-cells of the Eolis and Coryne were carefully compared together, and were found to be identical. 3rd. Dr. M'Bain and Dr. Wright found an *Eolis Drummondii* on a fine specimen of *Tubularia indivisa*. They first carefully examined the thread-cells of the Tubularia, and found four kinds, two (large and small) of a nearly globular shape, each containing a four-barbed dart, and two (large and small) of an almond shape, the larger one containing a thread furnished with a lengthened brush of recurved barbs. They then examined the papillæ of the Eolis, and found the ovate sacs filled with an indiscriminate mixture of all the four kinds of thread-cells found on *Tubularia indivisa*. 4th. Dr. M'Bain and Dr. Wright found a specimen of *Eolis Landsburgii* on *Eudendrium rameum*. *Eudendrium rameum* was furnished, as to the bodies of its polyps, with very large, bean-shaped thread-cells, in which an unbarbed style could be detected, while the tentacles of the polyps were covered with exceedingly minute cells. They compared the thread-cells of the Eudendrium with those found in the sac of Eolis, and found both kinds identical. Lastly, Dr. Wright had kept the specimen of *Eolis Drummondii* above mentioned fasting for a long time, and then introduced it to a large specimen of *Coryne eximia* fresh from the sea. The next morning every polyp of the zoophyte had vanished, and the ovate sacs of the Eolis were packed with the distinctive thread-cells of the Coryne, mixed with a few thread-cells of *T. indivisa*, the remains of its former feast. He also found the thread-cells of *C. eximia* in the alimentary canal. It was at one time supposed that thread-cells, or Cnidæ as Mr. Gosse had named them, were only to be found in the Hydroid and Helianthoid polyps and the Medusæ; Professor Allman afterwards discovered them in a species of Loxodes, a protozoan animalcule; and Dr. Wright had the good fortune to find them on the tentacles of an Annelid, *Spio seticornis*, and also on the tentacles of Cydippe, one of the Ctenophora. Since then he had observed them on the very minute tentacles of Alcinöe, another of the

Ctenophora. In all these classes of animals thread-cells were developed within the ectodermal coat of the animal, and in many, such as in *T. indivisa,* each within a distinct and very apparent sac, and not in connection with the digestive system.* The type of structure, moreover, of the thread-cell in the Protozoon, the Hydro-medusa, the Annelid, and the Ctenophore, was essentially different for each class; and this fact alone would lead an observer to doubt as to the origin of the thread-cells of Eolis, which so exactly resembled those of the Hydro-medusæ in their structure. Nevertheless it was certainly a very strange fact, for a fact the author firmly believed it to be, that one animal should be furnished with apparatus for storing up and voluntarily ejecting organic bodies derived from the tissues of another animal devoured by it, and that these should still retain their distinctive functions unimpaired; and he stated that his friend, Mr. Alder, one of the highest authorities on the Nudibranchi, still hesitated to assent to the doctrine sought to be proved by the present communication, on the ground of its extreme improbability. He should therefore feel obliged to any of the members of the society or others who would lend their aid to the confirmation or disproof thereof.

* This remark only applies to the Hydroids and their medusoids amongst the zoophytes. In the Actiniæ, Lucernarian Medusæ, and Lucernaria, thread-cells are found in connection with processes of the endoderm, related to the reproductive apparatus.

TRANSLATION.

On the DEVELOPMENT *of* ECHINORHYNCHUS. By Prof. RUD. LEUCKART.

(*From the 'Göttingen Nachrichten,'* No. 22, October 22nd, 1862.)*

The Echinorhynchi, or Acanthocephali, constitute a group of entozoa with respect to whose development and life-history we are confessedly at present wholly ignorant.

The observations of Von Siebold and of Dujardin have, it is true, shown that the ova of these worms contain an embryo wholly unlike its parents; but how, or under what circumstances, this embryo is developed into the perfect animal, in the absence of direct experiments, we have been left, up to the present time, merely to surmise. Most observers, and in particular Van Beneden and G. Wagener, have been disposed to assign to the *Echinorhynchi*, a simple metamorphosis hardly, perhaps, more remarkable than that which has been shown to take place in some of the Nematoidea. The latter helminthologist goes so far even as to believe that the organization of the perfect animal may be discerned in the embryo. The hook-apparatus at the anterior end of the body of the embryo would in this view be comparable to the proboscis of the perfect worm, and a pair of strap-shaped organs in the interior (which exist, it should be said, only in one species) have been assumed to represent the so-called "lemnisci."

In order to put these views to the test, I resolved, in the course of the last summer, to institute a series of experiments with the ova of *Echinorhynchus Proteus*, a species which abounds in our river fish, and particularly in those of the Perch tribe.

In the common *Gammarus Pulex* of our ponds and brooks, I had already noticed, on several occasions, *Echinorhynchi*

* The interesting paper of which we here give a translation constitutes the third of a series of 'Experimental Researches in Helminthology' instituted by its distinguished author.

with the neck retracted, and having the sexual organs undeveloped. From all appearance these were waiting to be transferred to the intestine of a higher animal, and from the construction of their proboscis the suspicion was awakened that they might be derived from *Echinorhynchus Proteus*. Induced by these circumstances I selected *Gammarus Pulex* as the subject of my researches. Having placed abundance of these crustaceans in a vessel of water, I introduced into it the ova afforded from six or eight female *Echinorhynchi*, and in the course of a few days had the satisfaction of detecting not only numerous ova in the intestinal canal of the *Gammari*, but also of seeing that the embyros had quitted the egg-shell, and had made their way through the walls of the intestine into the visceral cavity, whence they had wandered in various directions into the appendages, and had begun to grow. In a short time I was thus convinced, that in *Gammarus pulex* I had discovered the true intermediate supporter of the entozoon.

The ova of *Echinorhynchus Proteus*, in form and structure, resemble those of the allied species. They are of a fusiform shape, and surrounded with two membranes, an *external*, of a more albuminous nature, and an *internal*, chitinous. When the eggs have reached the intestine, the outer of these membranes is lost, being in fact digested, whilst the inner envelope remains until ruptured by the embryo, usually in the middle.

The embryo when it quits the egg measures 0·056 mm. in length, and 0·014 mm. in thickness. The hinder extremity is attenuated and pointed, the anterior truncated obliquely towards the ventral aspect. The surface thus formed, and which may be termed the vertex, supports a bilateral apparatus of spines. I counted five (rarely six) spines, which are inserted, at a certain distance on each side of the median line, in an expanded arch; so that the central spine, which is also the longest of all (0·002 mm.), occupies the highest position. Neither root nor claw can be distinguished in these spines. They present the appearance of straight ridges closely applied to the cuticle, and project only at the extremity in the form of a blunt point. Between the two halves of this apparatus of spines may be seen, close to the median line, on each side, also another short chitinous elevation or ridge, which constitutes with the above described spines, a more or less perfect right angle. G. Wagener regards these ridges as a pair of lips, between which is placed a slit-like pone, but in reality they are merely thickenings of the cuticle, which afford a firm point of insertion for the contractile substance of the embryo.

That this is really the case is shown most completely when an opportunity is afforded of observing the mode in which the embryo performs its boring movements. In this manœuvre the terminal surface with its two ridges is introverted, or rather its two sides are folded towards each other, and brought into contact throughout their entire length, the points of the spines being thus disposed in a line on either side, from which position, in a few seconds, by a simultaneous opening out of the folded surface they are moved to the right and left in a downward, or, if the expression be preferred, in a backward direction.

The parenchyma of the body is colourless and transparent. But at the same time there may be distinguished in it a firmer peripheral layer immediately covered by the cuticle, and which below the terminal surface forms a knob-like projection (regarded by Wagener as a "sac,"—perhaps a stomach?), and a more fluid medullary substance of a fine granular consistence. That the peripheral layer, notwithstanding its apparent homogeneousness, is contractile, is proved beyond doubt by the movements of the terminal disc. Moreover, the motions of the embryo are not confined exclusively to the act of boring. The body may occasionally be seen to contract both longitudinally and transversely. It may be seen also now and then to bend itself in various directions; and in transparent specimens of *Gammarus* this mobility is manifested in the circumstance that the young parasites are constantly changing their place in the interior of their host, slowly progressing sometimes among the viscera, sometimes among the muscles, and migrating from the visceral cavity into, and even penetrating, perhaps, to the extremity of the appendages, whence they return to their original site.

The only distinct structure perceptible in the interior of the embryo is a comparatively large (0·014 mm.) oval-shaped, granular mass, which occupies nearly the whole of the central part of the body, and is occasionally lodged in what has the appearance of a vacuolar space. Von Siebold, who has already recognised this granular mass as a constant organ in the Echinorhynchus-embryo, explains it hypothetically as being a remnant of the vitellus. Although at a subsequent period this body exhibits a distinctly cellular structure, it appears at this time to be a mere agglomeration of granules, characterised by their considerable size and strong refractive power. Similar granules are also found isolated here and there in other situations in the interior of the embryo, imbedded in fact in the softer internal substance, together with which, during the contractions of the peripheral layer, they may not unfrequently be seen to be propelled in different directions. The granular mass, moreover, itself lies free in the interior of this substance, and without any connection with the peripheral layer of parenchyma, as may be readily proved not only from the circumstance that it may be easily squeezed out of the embryo, but in a more direct manner from the fact that it is seen to change its place on the occurrence of any powerful peristaltic movement.

During the first fourteen days after the commencement of its migration, the morphological development of the embryo undergoes no change. It merely increases in size, and this so rapidly that at the end of this period some individuals are met with measuring in length 0·6 and 0·7 mm., and having a transverse diameter of 0·15 mm. The embryo during all this time retains the spines at the anterior extremity, but the form of this extremity is so far changed that the dorsal surface above the vertex projects in the form of a transparent hemispherical eminence, which forms with the neutral surface an angle of about 100°, whose apex is constituted by the meeting of the two parallel longitudinal ridges above described. It is clear that the presence of these ridges interferes, to a certain extent, with the equable expansion of the anterior end of the body, and it is to this circumstance that is due the peculiarity of comformation of the anterior part of the head. The spines, like the ridges, retain their former proportions and respective position. They are placed close to the longitudinal ridges on the sides of the cephalic surface, which by this time has become raised into two rounded eminences. At this stage I have never observed any true boring movements, although the forepart of the body is still occasionally retracted. It would seem, nevertheless, as if the spines were still of some use in the locomotion of the embryo, affording it, as they do, the means of affixing itself.

In consequence of this change of form of the anterior end of the body, the embryo has now acquired a more regular fusiform shape, which becomes more manifest when it has been rendered rigid and motionless by the endosmotic absorption of water.

But the growth of the embryo is not limited merely to the outer body. The nuclear granular mass in the interior has also considerably increased in size (in embryos of 0·7 mm. long to 0·09 mm.). Whilst at the same time it has lost its original granular aspect. Instead of the granules, pale cells are now seen measuring from 0·007 to 0·02 mm. in size, and continually multiplying. These cells constitute a compressed, almost spherical ball, with a well-defined outline. The surrounding parenchyma, as at an earlier period, consists of a fine granular substance, of nearly fluid consistence, out of which, moreover, on prolonged contact with water, numerous clear drops about 0·38 mm. in diameter exude, which at first present a perfectly homogeneous aspect, but, subsequently, in consequence of their undergoing a sort of coagulation, exhibit a regular nucleus of considerable size (0·016 mm.), and strongly refractive power. That these bodies, notwithstanding their cellæform structure, are not a normal constituent of the embryonal body, is clearly manifest from the circumstance that they may be seen gradually forming during the examination, and disappearing as soon as the object is floated in a thin solution of albumen—a proceeding which it is advisable to adopt upon other grounds as well.

The peripheral layer of contractile substance still retains its former condition, except that, of course, it has increased in thickness, and become more sharply defined on its inner surface. Its greatest thickness is still, as before, towards the anterior end of the body, although the knob-like projection has in the meanwhile disappeared.

After the embryo has attained the dimensions just stated without any other essential change, it begins, in the course of the third week, to exhibit a most wonderful metamorphosis. The nucleus, which up to this time has been constituted of a simple, small aggregation of cells, now increases rapidly in size, and at the same time elongates, and becomes transformed by a definite grouping of its elements into a complex organism, in which, after a short time, may indubitably be recognised the features of a young *Echinorhynchus*. During this process, however, the body of the embryo remains unchanged, except that it is slightly larger (up to 0·09 mm.), and presents, in the cortical layer, yellow granules constantly increasing in number, and which necessarily offer no slight obstacle to the further study of the processes going on in the interior.

The embryo of *Echinorhynchus*, therefore, stands in the same relation to the future worm that the *Pluteus* does to the Echinoderm or the *Pilidium* to *Nemertes*. As in those cases, *so in Echinorhynchus, the ultimate animal arises in the interior of the primordial body*, by a process which presents so close an analogy with the production of an embryo, and, consequently, with the act of generation, that one feels inclined at once to identify it with such an act, and, consequently, to regard the *Echinorhynchus* as exhibiting, instead of a metamorphosis, an alternation of generations in its mode of development.

Without going into minute particulars with respect to the transformation of the cellular mass in the *Echinorhynchus*, still a few words may be said regarding the most important points concerned in this metamorphosis.

As before remarked, this process commences in a defined and regular grouping of the cells which had previously been united into a simple ball. Next, it may be seen that the anterior end of the ball becomes defined from the rest, or rather, that in consequence of a clearing up in its interior, it is transformed into an almost lenticular vesicle, whose outer wall is constituted of a thin layer of cells, and is usually distinguished by a number of yellow granules. Subsequent observation will show that this transparent vesicle is the rudiment of the cavity of the proboscis. Behind this part will be seen an oval mass of cells of considerable size, extending backwards in the axis of the body to about the middle of its length, and in its posterior half enclosing a smaller, though still a considerably sized cellular body. This body is the future ganglion, whilst its envelope represents the future proboscis-sheath. At the hinder end, again, of this part are attached, also in the axis of the body, several small collections of cells, which are sometimes crowded together, sometimes arranged one behind the other, in a longitudinal series, and which, together with the terminal portion of the nucleus, go to constitute the sexual apparatus together with the so-termed suspensory ligament. The lateral walls of the middle portion of the body, bounded in front by the cavity of the proboscis, and behind by the terminal portion of the reproductive organs, and which, at first, are of very considerable thickness, are destined to form the future muscular tunic or sac of the *Echinorhynchus*. At this time no trace of visceral cavity is perceptible.

The next changes in the young *Echinorhynchus* consist in its continued and rapid growth in length to twice or thrice its original dimensions, without any increase in its transverse diameter. The growth is limited almost entirely, however, to the middle section of the body, or that which is surrounded by the lateral walls, and the form of this part consequently becomes more and more cylindrical as the growth proceeds. At the same time the walls of this part become thinner; whilst the inclosed organs, the proboscis-sheath, and the sexual organs appended to the so-termed "ligament," notwithstanding all the stretching, retain their original plump form almost unchanged. The most remarkable alteration is the lengthening of the cavity of the proboscis, which continues to extend backwards deeper and deeper into the proboscis-sheath, in consequence of which it gradually acquires a club-shape.

When the young worm has reached the length of from 0·4 to 0·45 mm., or about half that of its parent, a space becomes perceptible between the integument and the viscera, and which represents the commencement of the visceral cavity. This space is widest and most distinct in the annular segment between the sheath of the proboscis and the ligament. And in this situation may now be perceived in their proper places on either side, a pair of short and thick retractor muscles, extending in a straight line from the end of the proboscis-sheath to the contiguous wall of the body. And about this time, I think, may be observed the first traces of certain differences in the position and form of the internal sexual organs, which may be taken, I conceive, to indicate a sexual difference.

Up to this stage the anterior and posterior half of the body have continued to grow pretty nearly in an equal ratio. But now the growth of the latter begins more and more to preponderate. The points of insertion of the retractor muscles recede further and further backwards, and the suspensory ligament, which at first could hardly be distinguished as an independent structure among the crowded parts constituting the sexual apparatus, becomes more and more evidently the supporter of those organs. In its uppermost part, two oval swellings may be perceived in it, which partially overlap each other, and represent the first rudiments of the male and female reproductive glands, as the case may be. Some way behind these is a short, cylindrical portion, surrounding the lower end of the ligament like a sort of sheath. In the female this is the first rudiment of the so-termed uterine-bell or tube. In the male, in which from the first it has a somewhat different aspect, it becomes afterwards the vas deferens and vesicula seminalis. Posteriorly this median organ terminates in an almost spherical end, at this time nearly completely enveloped by the muscular wall of the body; and which, in the male, becomes more and more evidently recognisable as the rudiment of the bell-shaped penis, whilst in the female it is transformed into the vagina, whose upper end is not developed into the elongated, so-termed "uterus," until afterwards, as the time of sexual maturity approaches.

The preponderating growth, both in length and thickness, of the posterior half of the body continues to be more and more manifest, so that the anterior segment, with the proboscis-sheath, and proboscis-cavity, which now reaches as far as the ganglion (but little increased in size), acquires more and more the aspect of a cervical appendage to the proper body.

In the meanwhile, the worm has gradually become so large as almost completely to fill the interior of the embryo. But notwithstanding this, the latter has undergone no change, except in the continued multiplication of the yellow granules beneath the contractile cortical layer, and the appearance of vesicular cells (0·007 mm.) in that layer. It contracts and stretches itself as be ore, and is in continued motion within its host. Its movements, however, appear on the whole to be less effective than they were, owing to its free movements being interfered with by the worm in its interior.

Having traced the young *Echinorhynchus* up to this stage of development, I expected every moment to witness its liberation from the original embryo. But I was again astounded to find that this liberation never took place. *The embryonic body, with its cortical layer and yellow granules, is persistent during the whole of life, and gradually becomes closely attached to the worm, which is developed from the metamorphosis of the nucleus in the manner above described.* It is transformed, in fact, into the tunics external to the muscular sac, and which from their thickness and granular texture, as well as from the existence in them of a distinct vascular system, as has been long known, constitute one of the most striking characters of the Acanthocephali.

Properly speaking, however, it is not actually the whole embryonal body which is transformed into this tunic. The original cuticle, together with the spines, is thrown off, as soon as the *Echinorhynchus* occupies the whole interior of the embryo. But this shedding of the cuticle is in any case of but little importance, and scarcely to be compared to the mode in which *Nemertes* slips out of its *Pilidium.*

It should, moreover, be remarked, that I have not directly observed the shedding of the embryo-cuticle, and only conclude that it takes place from the circumstance that Echinorhynchi of about 1 mm. in length no longer present the embryonic form of head, and are not furnished with spines. The primary embryonic body, which at first might be regarded as, to a certain extent, an independent animal, after the loss of the original cuticle accommodates itself more and more accurately to the form of the *Echinorhynchus.* And this is the more remarkable when it is considered that the growth of the latter from this time proceeds at a very rapid pace.

As at an earlier period in the inclosed worm, so now in the entire body may be distinguished a somewhat ventricose oval trunk, containing the reproductive organs, whose sexual differences are now very manifest, suspended by the ligament, and a much contracted cylindrical neck, inclosing and almost entirely occupied by the proboscis-sheath with its contents. In worms of a large size, even at this stage, the extremity of the neck, which corresponds to the anterior vesicular expansion, or proboscidian vesicle before described, but which at this time has become much contracted, and transformed into a slender muscular apparatus (*m. retractor proboscidis*), is prolonged in the form of a distinct though small capitulum. The anterior border of the proboscis-sheath is inserted into the neck of this capitulum, in which, notwithstanding the absence of the hooklets, even now the future proboscis cannot fail to be recognised.

As growth continues, however, the connection between the muscular sac and the enveloping body becomes closer and closer. At first there exists between them a continuous interspace filled with the remains of the fluid parenchyma, which is so abundant in the embryo, and this parenchyma, with its yellow granules, may be seen to be propelled in any direction, in obedience to the contractions of the body, but, by degrees, this movement becomes limited to certain spots, and confined more and more to narrow passages. In other words, the muscular membrane and external layer continue to grow more and more together, in consequence of which the original space is transformed into a system of intercommunicating canals.

I must also mention that the motions of the worm, after the shedding of the embryonic cuticle, become not only weaker and more limited in extent, but also gradually assume a different character. In place of the earlier creeping or crawling movement, will now be remarked nothing but still slower oscillatory motions in the extremities of the body, and more or less extensive constrictions, limited for the most part to the trunk, and dependent, doubtless, upon the action of the newly-formed muscular walls, although their histological development has at this period made but little progress.

When the worm, by continued growth, especially of the genital organs, has acquired a length of about 4 mm., the appearance of the hooklets marks its entrance into the last stage of development. The hooklets arise first on the summit of the head, but it is very remarkable that they do not spring from the outer cuticular tunic, but from the inner membrane, which might be regarded as the limitary layer of the original proboscis-cavity. They are developed from a special layer of cells which originate in the subcuticular granular layer, and which is especially related to the inner tunic of the head. Before the hooklets, which first make their appearance, are fully formed, the formation of the rest begins, so that the entire proboscis is soon completely armed. But as soon as this armature is completed the proboscis is retracted, the retraction commencing by the introversion at first of the vertex into the neck, and afterwards when the introversion by the continued growth of the body extends beyond this part, into the proper cavity of the body. Thus it is only at a later period that that peculiar conformation is assumed which has been so often remarked in the *Echinorhynchi*, frequently met with in an encysted condition in the flesh and intestines of fish, and what has been compared with the conditions presented in the Cysticerci. The form of the *Echinorhynchi* is at first rather slender, and almost fusiform. It would seem to require some time to assume the rounded shape.

When the introversion of the neck begins will be observed for the first time the commencement of the so-termed "*lemnisci*," which are at first short and contracted. With respect to the origin and relations of these organs to the peripheral vascular system, I am at present unable to make any positive statement. Nor have I as yet investigated the changes undergone by these entozoa after they have reached the intestine of their ultimate host; but this investigation shall be undertaken on the first opportunity. Considering the relatively high development of the young parasites, these changes, it may be presumed, will be found to be but simple, and probably passed through in the course of a few days, whilst the metamorphosis of the embryo, up to the formation of the *Echinorhynchus*, occupies, on the whole, about six weeks.

In conclusion, I would, moreover, remark that the parasitism of the young *Echinorhynchi* is not unfrequently fatal to their entertainer. This is particularly the case in those instances in which the parasites are numerous—in some I have seen fifty or sixty,—and in the later stages of their development. In the young state, these entozoa, notwithstanding the freedom with which they exert their boring powers, are but little injurious.

GIESSEN; Aug. 28th, 1862.

REVIEWS.

On the Germination, Development, and Fructification of the Higher Cryptogamia, and on the Fructification of the Coniferæ. By Dr. WILHELM HOFFMEISTER. Translated by FREDERICK CURREY, M.A., Sec.L.S. London: printed and published for the Ray Society, by Robert Hardwicke.

WHETHER or not Linnæus intended by the term Cryptogamia to express a doubt about the sexuality of flowerless plants which one day might be cleared up, there is no doubt that many of the earlier observers suspected that the same conditions of reproduction existed in the lower as well as the higher plants. It was not, however, till the remarkable discoveries of Suminski with regard to the fructification of ferns, and the demonstration, not only of the existence, but of the function of sperm-cells and germ-cells in these cryptogams, that general attention was drawn to the subject. A host of observers have come upon the field, and we are now almost in a position to lay it down as a law, that throughout the whole vegetable kingdom there is going on a reproductive process, involving the union of two dissimilar cells—a germ-cell and a sperm-cell. In the lower cryptogamia there are many cases in which this has not been demonstrated; but in the higher cryptogamia it has been done for the whole series. Science is largely indebted to the labours of Dr. Hoffmeister for this result; and he has not only laboured as an original observer, but has collected together, with an industry and pains-taking diligence which is altogether German, all that has been done by others on the subject. His first published work on this subject was produced at Leipzig, in 1847. Since that period, however, much has been done, and Dr. Hoffmeister, in the 'Transactions' of the Royal Academy of Saxony, and in the 'Regensberg Flora,' has added much original matter to his first observations. In 1852, the Ray Society had brought before it a proposition for the translation of Hoffmeister's work. This was, however, not entertained at the time, as a London publisher advertised a translation of the same. This translation, however, never saw the light; and in 1859 Mr. F. Currey, who was himself well acquainted with the subject, undertook to correspond with Dr. Hoffmeister on the subject of a translation of his labours on

Cryptogamic Botany, and the result has been the production of this work. It should therefore be understood, that this present volume is not a translation of Dr. Hoffmeister's original work, nor a new edition of it, but a new work. It is, indeed, founded on the author's first work, but not only have the papers before alluded to been added, but the author has contributed also a large quantity of new matter, and revised the whole work, so that it is really a complete record of all that is known at present. This is not only the case with the letter-press, but also with the plates. The work is illustrated with no fewer than sixty fine plates, all of which have been prepared for this work by the author, and engraved by Mr. Tuffen West.

It would be impossible for us here even to give a sketch of the grand series of observations of which this work is the exponent. Each group of plants belonging to the higher cryptogamia is subjected to a searching investigation, sometimes by Dr. Hoffmeister, and sometimes by French, but more frequently by German observers. We wish we could say that we sometimes find the name of an English observer, but the higher cryptogamia is not the field of English triumphs. Dr. Hoffmeister commences with the structure of Anthoceros, and passes on to the leafless and leafy Jungermanniæ. To these succeed the Marchantiaceæ, the mosses and ferns. Equisetaceæ with Pilularia, Marsilea Salvinia, Isoetes, and Selaginella, are the groups which lead to the Coniferæ, standing on the outside of the cryptogamic group. We may spare ourselves any further review of the work by presenting the author's own summary of his labours:

The comparison of the development of the mosses and liverworts on the one hand, with that of the ferns, Equisetaceæ, Rhizocarpeæ, and Lycopodiaceæ on the other, discloses the most complete uniformity between the fruit-formation on the one hand and the embryo-formation on the other. The structure of the archegonium of the mosses—the organ within which the fruit-rudiment is formed—is exactly similar to that of the archegonium of the vascular cryptogams, the latter being that part of the prothallium in the interior of which the embryo of the frond-bearing plant originates. In both the large groups of the higher cryptogams there is a cell which originates freely in the larger central cell of the archegonium, by the repeated division of which (free) cell, the fruit of the moss and the frond-bearing plant of the fern are produced. In both, the divisions of this cell are suppressed and the archegonium miscarries, unless, at the time of the opening of the top of the latter, spermatozoa find their way to it.

Mosses and ferns therefore exhibit remarkable instances of a regular alternation of two generations very different in their organization. The first generation—that from the spore—is destined to produce the different sexual organs, by the co-operation of which the multiplication of the primary mother-cell of the second generation, which exists in the central cell of the female organ, is brought about. By this multiplication a cellular body is produced which in the mosses forms the rudiment of the fruit, and in the vascular cryptogams, the embryo. The object of the second generation is to form numerous free reproductive cells—the spores—by the germination of which the first generation is reproduced. The leafy plant in the mosses answers therefore to the prothallium of the vascular cryptogams; the fruit in the mosses answers to *the fern* in the common sense of the word, with its fronds and sporangia. The pro-embryo, that is to say the confervoid process produced by the germinating spore of most of the mosses and many of the liverworts, cannot be looked upon as a special generation any more than the similar organ (the suspensor) in phænogams. It is to be remembered that when new individuals are produced from single cells of the leaf of a moss, and also during the development of the gemmæ of many mosses, the formation of the rudiment of the first leafy axis is preceded by the formation of a similar confervoid pro-embryo. This holds good as well in the mosses* as in those liverworts which possess a pro-embryo. When new individuals are formed from the fragment of a leaf of *Lophocolea heterophylla* or of *Radula complanata*, the cell of the surface of the leaf which becomes the mother-cell of the new plant produces in the former of the above-named plants a single or double row of cells, and in the latter a cellular surface. In each case the body produced is exactly similar to the pro-embryo which originates from the germinating spore in both species.

The vegetative life of the mosses is confined exclusively to the first, and the fructification to the second generation. The leafy stem alone sends forth roots: the spore-forming generation draws its nourishment from the first generation. The life of the fruit is usually much shorter than that of the leaf-bearing plant. In the vascular cryptogams this state of circumstances is reversed. It is true that the prothallia send out capillary roots: this is always the case in the Polypodiaceæ and Equisetaceæ, and frequently in the Rhizocarpeæ and Selaginellæ. But the prothallium lives a much shorter time than the leaf-bearing plant, which latter, in most cases, does not produce fruit for several years. The contrast, however, is not so marked as it appears at first sight. The apparently unlimited life of the leaf-bearing moss depends merely upon continual renovation. Phenomena of a similar kind are met with in the sprouting prothallia of Polypodiaceæ and Equisetaceæ. In the lowest liverworts (Anthoceros and Pellia) the structure of the fertile shoots is less complicated, and their duration little longer, than that of the fruit. On the other hand the ramification of the prothallium of the Equisetaceæ is very variable; its life is not of shorter duration than that of an individual shoot.

It is a circumstance worthy of notice that in the second or spore-forming generation of mosses and ferns, complicated thickenings of the cell-walls usually occur (witness the teeth of the peristome in mosses, the capsule-wall and the elaters in liverworts, and the vessels in ferns), whilst in the first generation these thickenings are rare and exceptional.

An unprejudiced consideration of the subject will show that the separation into two groups only of the plants comprising the mosses on the one hand, and the liverworts (Jungermannieæ, Marchantieæ, Anthoceroteæ, and Riccieæ) on the other, is not natural. There is no marked feature by which these two groups can be distinguished. It is true that a pro-embryo like that in the mosses is wanting in most of the genera of liverworts, especially in all the leafless ones. Many leafy Jungermannieæ, however, especially the true Jungermanniæ, exhibit the phenomenon

* W. P. Schimper's excellent work, 'Recherches sur les mousses,' renders it unnecessary for me to cite examples.

of the conversion of the germinating spore into a single row of cells, one of which cells, by repeated divisions in all three directions of space, becomes the rudiment of the leafy axis. This phenomenon is as well marked as in any of the mosses. The outward form of the antheridia and archegonia in the two groups differs very slightly. The first stages of development of the fruit-rudiment of the mosses on the one hand and the Jungermanniæ on the other, are, it is true, very different. In the former the longitudinal growth is caused by the continually repeated division of a single conical apical cell of the organ, by means of septa inclined alternately in two directions; in the latter this growth is caused by the repeated division by horizontal septa, of four cells constituting the upper end of the fruit-rudiment. But the normal mode of cell-multiplication in the fruit-rudiment of the Marchantieæ (including the Targionieæ), and of the Riccieæ, coincides exactly with that of the mosses. Lastly, Anthoceros exhibits a form of cell-multiplication of the endogonium which is the same as that of the punctum vegetationis of the ends of the axes of a great number (probably the majority) of phænogams. The septa produced in the one apical cell of the organ, are inclined in regular succession towards the four points of the compass. The presence or absence of a columella, or of elaters in the ripe fruit, are points of no characteristic value; Anthoceros has the columella, but this genus and the Riccieæ have no elaters. Radula in the Jungermannieæ has a vaginula, and so has Anthoceros.

Upon instituting a closer comparison between the mode of development of different forms, four types soon become conspicuous, around which all the phenomena hitherto sufficiently investigated may be conveniently arranged. We thus arrive at the following equivalent groups, which are not however equally rich in the number of genera and forms.

1. Mosses according to the ordinary limits of the family, including the Sphagnaceæ.

2. Jungermannieæ; in which the leafy ones are connected with the leafless ones by a succession of intermediate stages.

3. Marchantieæ, Targionieæ, and Riccieæ; all intimately connected with one another by the similarity of the earliest conditions of the fruit, as well as by many vegetative phenomena.*

4. Anthoceroteæ.

The mode in which the second generation originates from the first is much more various in the vascular cryptogams than in the others. All ferns however agree in the fact that the first axis of their embryo has only a very limited longitudinal development; it is an axis of the second order which breaks through the prothallium and becomes the principal axis; and they all agree further in this, that the end of the axis of the first order never forms the root. All vascular cryptogams are without main roots; they have only adventitious ones.

In more than one respect the formation of the embryo of the Coniferæ is intermediate between the higher crytogams and the phænogams. Like the primary mother-cell of the spores of the Rhizocarpeæ and Sellaginellæ the embryo-sac is one of the axile cells of the shoot, which in the one case becomes converted into the sporangium, in the other into the ovule. In the Coniferæ also the embryo-sac soon becomes free from any mechanical connexion with the surrounding cellular tissue. The filling of the embryo-sac by the endosperm may be compared with the production of

* As, for instance, the precisely similar succession of the shoots; the separation of the tissue of the shoots into an upper layer with intercellular cavities, and a lower layer without cavities; the occurrence of peculiar thickenings upon the inner wall of the capillary roots, &c.

the prothallium of the Rhizocarpeæ and Selaginellæ. The structure of the corpuscula bears the most striking resemblance to that of the archegonia of the Salviniæ, and still more of the Selaginellæ. Irrespective of the different mode of impregnation—which in the Rhizocarpeæ and Selaginellæ takes place by free spermatozoa, and in the Coniferæ by a pollen-tube, in the interior of which spermatozoa are probably formed—the transformation of the germinal vesicle into the primary mother-cell of the new plant in the Coniferæ and the vascular cryptogams, only differs in the fact, that in the latter there is usually one single germinal vesicle only, whilst in the former there are very numerous germinal vesicles, of which, normally, one only is impregnated. The embryo-sac of the Coniferæ may be looked upon as a spore remaining enclosed in its sporangium; the prothallium which it forms does not come to the light. In order to reach the archegonia of this prothallium the impregnative matter must make itself a passage through the tissue of the sporangium.

Moreover, the development of the pollen of the Coniferæ, when dispersed, varies in a marked manner from that of phænogams, and exhibits vital phenomena similar to those met with in the microspores of Pilularia, Salvinia, and Isoetes. The extinction of its sexual function (the protrusion of the pollen-tube) is preceded by a cell-formation in its interior, of which no instance is to be found amongst monocotyledons and dicotyledons.

Two of the phenomena which have led me to compare the embryo-sac of the Coniferæ with the large spores of the higher cryptogams, is common to the embryo-sac of phænogams, viz., the origin of the ovule from an axile cell, and the want of connexion with the adjoining cellular tissue. This is very remarkable in the Rhinanthaceæ on account of the independent growth of the embryo-sac. The Coniferæ are closely allied to the phænogams in the fact that their pollen-grains develope tubes.

The phænogams therefore form the upper terminal link of a series, the members of which are the Coniferæ and Cycadeæ, the vascular cryptogams, the Muscineæ, and the Characeæ. These members exhibit a continually more extensive and more independent vegetative existence in proportion to the gradually descending rank of the generation preceding impregnation, which generation is developed from reproductive cells cast off from the organism itself. The closing members of this series, the Characeæ, pass through their entire vegetative development in this generation, whilst the vital phenomena of the generation which follows impregnation are limited to the filling with oil and starch of the newly-formed cell in the central cell of the fruit-branch or archegonium. The development of the latter generation in the Muscineæ is far more important, although in some instances, as for example in Riccia, it is very limited in comparison with the first generation, that, namely, which precedes impregnation.* This state of things is reversed in the Ferns, the Equiseta, and the Ophioglosseæ. From the Characeæ up to these orders, there is an uncertainty in the different species as to the sexual function of the reproductive cells which are cast off from the organism itself, viz.,

* Anthoceros—which in the development of the second generation stands very low in the scale—exhibits a remarkable analogy with the Characeæ, in the fact that, as in the latter, the formation of its antheridia commences by the growing out of the cells of the wall of an intercellular cavity. The well-known red globules of Chara are manifestly states of antheridia. Cavities communicating with one another are formed round the middle point of the hitherto solid globular mass of cells, within which cavities the antheridia—or cellular threads in whose joints the vesicles which produce the spermatozoa are formed—become developed.

the spores. In these orders species nearly allied to one another are partly monœcious and partly diœcious. Certain species amongst the Charæ, Muscineæ, the Ferns, and the Equiseta,* produce both kinds of sexual organs, archegonia and antheridia, upon the same individual of the generation preceding impregnation: the latter are always produced before the former. In other Characeæ, Muscineæ, and Equiseta, the male and female sexual organs are distributed upon different individuals —a separation which is very complete in certain species of mosses, and not in others. The spores from which, in the Characeæ, Muscineæ, and Equiseta, diœcious prothallia are developed, exhibit no indication of the sex of the individual to be produced from them. But there is often a marked difference in the complete form between the male and female individuals: the former are much smaller than the latter; they are dwarfish. Extreme instances of this are to found, amongst mosses, in *Dicranum undulatum* and *Hypnum lutescens*. In the Equiseta also the male prothallia are always smaller than the females.

Lastly, the reproductive cells of the *Rhizocarpeæ*, *Isoetes*, and *Selaginella* exhibit, according to their sex, the most remarkable differences in their mode of development, size, and form, so long as they continue in vital connexion with the organism belonging to the generation following impregnation. In the Coniferæ the reproductive cells differ in their origin and formation but little from those of phænogams; they differ only in the nature of the vegetative growth subsequent to their formation —which growth in the Coniferæ is in a high degree independent—in the formation of the row of cells in the interior of the pollen-grain, as well as in the formation of the endosperm, and of the corpuscula in the interior of the embryo-sac.

There are so many essential points of agreement between the Coniferæ and the phænogams, that it is more to the point to get rid of the marked differences in their respective processes of embryo-formation, than to indicate in what they agree. One of these differences is the cell-formation inside the pollen-grain, but the principal one is the development of the endosperm and of the corpuscula, a process exactly analogous to the formation of the prothallia and archegonia of the vascular cryptogams, and which is entirely wanting in the phænogams. The whole series of developmental processes which occur in the Coniferæ between the filling of the embryo-sac with the cellular tissue of the endosperm and the production of the germinal vesicles in the corpuscula, is entirely passed over in the phænogams. Here the germinal vesicles are formed immediately in the embryo-sac. In the phænogams there is no vital phenomenon analogous to the development of the prothallia and of the endosperm of gymnosperns, just as in the cryptogams and the Coniferæ there is no analogue to the endosperm-formation which takes place in so many phænogams after the arrival of the impregnating organ at the embryo-sac. The breaking up of the pro-embryo of the Coniferæ into a number of independent suspensors is a phenomenon of the most peculiar kind, to which nothing amongst the vascular plants bears any resemblance,† and to which the division of the spore (*i. e.*, the mother-cell of the oospores) of

* The greater number of the Charæ and Muscineæ, a few only of the Equiseta, and all the known forms of Ferns and Ophioglosseæ.

† The formation of the pro-embryo of *Loranthus Europæus* out of four longitudinal rows of cells may be looked upon as a slight indication of this. One only of these cells, the terminal cell, becomes transformed into an embryonic globule. (Hoffmeister, in 'Abh. Kön. Sächs. Ges. d. Wiss.,' vi, 543.)

Fucus into several cells capable of impregnation and development* is hardly analogous, inasmuch as with the latter process the impregnation of the free spore commences and forthwith terminates.

The Microscope and its Revelations. By WILLIAM B. CARPENTER, M.D. Third Edition. London: Churchill.

THIS work, which has now reached its third edition, needs no commendation from us. It is undoubtedly the best manual on the use of the microscope in the English language. Nevertheless, this edition contains a large mass of new matter which claims our recognition. The classification of the Diatomaceæ has been remodelled in accordance with the views of Mr. Ralfs, and the account of that group has been considerably extended. The account of the Rhizopoda has been altogether rewritten, and that of the Infusoria has been augmented by a summary of Balbiani's recent researches on their sexual reproduction. As might be expected from the extent of the author's own researches on Foraminifera, the chapter on these organisms has been rewritten and greatly extended. Mr. Salter's researches on the teeth of Echinus, and those of Mr. Houghton on the parasitic habits of the larva of Anodon, have been embodied with the author's more recent views of the structure of the shell in the chapter devoted to the Mollusca. Additions have been made also to the account of the forms of Annelida, and the description of the structure of the shells of the Crustacea have been considerably modified. In the section devoted to Insects, Dr. Hicks' researches upon their eyes, and Mr. Beck's upon the Podura scale have been described. Amongst the new accounts of structure among the vertebrate animals, are those of Mr. Whitney on the circulation in the Tadpole. Mr. Rainey's important researches in "Molecular Coalescence" are also noticed in this edition. The work is still further improved by the addition of ten separate plates, and twenty woodcuts. Two of the plates, representing chiefly the circular forms of Diatomaceæ, are on steel, and form frontispieces to the work. It gives us much pleasure to recognise, in so large a quantity of the new matter which Dr. Carpenter has introduced into the present edition of his work, the results of researches which the 'Quarterly Journal of Microscopical Science' has been the means of introducing to public notice. We feel that the study of this work will be one of the best incentives to the student of the microscope to pursue his investigations in a spirit which will enable him to become a contributor to our pages, and a future helper of Dr. Carpenter in the subsequent editions of his work.

* Thuret, 'Ann. d. Sc. Nat.,' iv Sér., 1854, p. 273.

NOTES AND CORRESPONDENCE.

Note respecting Parasites found in the Blood of the edible Turtle.—In Vol. i, N. S., of this Journal, p. 40, is an account by Mr. Canton, of some fusiform ova, found by him adhering to the eyes of the edible turtle. Similar organisms have since been noticed by Dr. Leared, in the blood from the heart of the same animal, in two instances. In one of these latter cases, examined in August, 1860, the heart also contained numerous minute fluke-worms, which were pronounced by Dr. Cobbold to belong to an undescribed species of Distoma, and named *D. constrictum*, from its peculiar form. Whether the minute oviform bodies noticed by Mr. Canton, and these Distomata stand in any relation to each other is yet to be made out, and is an interesting subject for enquiry. Dr. Leared's account of the Distomata and oviform bodies will be found in vol. xiii. of the 'Transactions' of the Pathological Society, p. 271.

On the Terms used in the description of Diatoms.—Dr. G. Fresenius, in the 'Senckenb. Proc.' vol. iv., p. 63, describes and figures four species of Navicula, one being new. *Pinnularia Silesiaca*, Bleisch, and *Amphora selina*, W. Smith. In his introductory remarks he proposes the adoption of the terms, "frons" and "latus," to express what English observers call the "front view" and "side view." ('N. Hist. Rev.,' vol. ii., No. 8, p. 481.)

On the occurrence of Parasitic Sacs on Crustacea and some Insect-Larvæ.—Lieberkühn (Mull. 'Arch.,' 1856, p. 494) and Schenk ('Verh. der Phys.-Med. Gesells,' in Würzburg, 1858) have described certain organisms parasitic upon the gills of the larvæ of *Phryganea, Asellus aquaticus,* and *Gammarus pulex.* These organisms have been since examined by Professor Cienkowski, who considers them to be forms of a unicellular plant, to which, from the amæboid character of its zoospores and its parasitic habit, he has given the name of *Amœbidium parasiticum*. Cienkowski found the plant on *Phryganea* and *Gammarus pulex*, and also very plentifully on the larvæ of gnats. It is tubular or sac-shaped, unicellular and variable in form; the largest plants were 0·5 mm. long by 0·001 mm. broad; the smallest 0·015 mm. long. In the spring they produce in their interior spindle- or sac-shaped bodies, which escape through the cell-wall of the mother plant, being sometimes projected by the elastic contraction of that cell-wall. Pear-shaped zoospores are afterwards formed, which, when free, exhibit amæboid expansions and contractions, but are distinguishable from *Amœba diffluens*, which they much resemble, by the absence of a contractile cavity. These zoospores eventually become motionless, and at once produce spindle-shaped bodies (young amæbidia) in their interior, or they become transformed into resting spores, which, after a time, also produce young amæbidia. The author concludes that *amœbidium* is a plant belonging to the lower Algæ or Fungi. He then proceeds to describe a very singular growth, as to which he was long in doubt whether it belonged to or was parasitic upon amæbidium. He describes the stages of development of this growth, which is attached to the sides of the amæbidium, and, when perfect, consists of a large obovate or pear-shaped cell, crowned with moniliform rows of cells like the head of an *Aspergillus*. He concludes that it is a fungus, but of doubtful affinity, and calls it *Basidiolum fimbriatum*. ('Nat. Hist. Rev.,' vol. ii, No. 8, p. 477.)

Note on a simple Mounting for any Microscopic Objects.—Few microscopists use black japan as a mounting without having their objects occasionally spoiled by the running in of the cement. Having suffered, like my neighbours, from this difficulty, I have sought to obviate it by the use of various other methods of mounting, which should combine speed, ease, and certainty in their performance. One of these appears so far promising in utility, that I am induced to draw attention to it. It is performed as follows:

Little pieces of kid leather, wash-leather, or blotting-paper, about one inch square, have circular holes punched in the middle, the hole being somewhat smaller than the thin glass cover which is subsequently to be used.

The object having been prepared and placed upon the glass slip, or on the cover, if more desirable, one of the pieces of leather is brushed over with "liquid glue" (a thickish varnish made of shellac and naphtha). When covered on both sides with this cement, it is placed upon the glass slip, the cover put over it, and *gently* pressed down, to insure close contact without squeezing the cement out of the leather. It may then be put away. The cement soon dries, and at any subsequent time the superfluous leather may be cut away close round the edges of the thin glass cover.

Care should be taken that the leather or paper is soft, and free from elasticity, so that it may lie flat upon the glass; also that it has enough cement to insure adhesion, and not so much as to spread over the object when the cover is placed upon it. The consistency of the cement also requires attention; it should be just so fluid that it is readily absorbed by blotting-paper.

So far, I have found it combine the advantages of speed, ease, certainty, and cheapness, requiring no special appliances in its performance,—the liquid glue, bottle and brush being in constant use for other purposes, where cement or a yellow varnish is required, and the punch being the same that is used for cutting out labels, &c. The little squares of leather for thick objects, and of paper for thin objects, are all that it is necessary to keep specially for this purpose.—B. S. Proctor, 11, Grey Street, Newcastle-on-Lyne.

Plan for finding the Focal Length of Objectives.—If you think the following communication worth insertion, perhaps you will find it a place in the 'Journal.' It is a modification of Professor Thury's plan for finding the focal length of microscopic objectives. It was suggested by reading Captain Mitchell's paper in the October number of the 'Journal,' and may be of use to those who, like myself, wish to know the true focal length of their objectives, but have not a positive eyepiece micrometer. The difference from the professor's plan consists in using the eye-lens of the negative eyepiece only, the micrometer being placed, as usual, exactly in its focus. I send you a table of the results on my own objectives, also the magnifying power as given by the camera and my longest eyepiece, to prove the correctness of the method by comparison with the magnifying power obtained by multiplying the power of the objective by that of the eyepiece, the results being as coincident as unavoidable errors will allow. To arrive at this, I have, however, been obliged to differ from Captain Mitchell in considering the *power* of the objective to be the exact number that one of the stage covers of the eyepiece micrometer, and not with the addition of one, as in his method. Any one following out this plan will find that, as the power of the eyepiece must be the same with every objective at the same distances, it is impossible to make the results with that addition agree, particularly with the lower powers, where the proportion of one to the whole is so much greater, and where all errors are as a minimum.

It is necessary to have the same distance from the stage micrometer to the focus of the eye-lens in measuring the magnifying power with the camera, as between the two micrometers in measuring the power of the objective; ten inches, when possible, being most convenient. The adjustment of the objective to be always at the same place.

Table of objectives.—Distances of micrometers divided by the number of eyepiece micrometer equal to one of stage plus one.—Focal length—Magnifying power by multiplying number by 5 (power of eyepiece).—Also magnifying power by camera at ten inches, with longest eyepiece—The adjustment ring in a line.

		Focal length.	No. × 5.	Magnifying power by camera.
$\frac{1}{8}$	$\dfrac{\text{D—10-in.}}{\text{No.} + 1 = 83{\cdot}5} =$	·1197 .	412 .	406·
$\frac{1}{4}$	$\dfrac{\text{D—10}}{\text{No.} + 1 = 52{\cdot}2} =$	·191 .	256 .	256·
$\frac{1}{2}$	$\dfrac{\text{D—10}}{\text{No.} + 1 = 25{\cdot}6} =$	·390 .	123 .	123·
1	$\dfrac{\text{D—10}}{\text{No.} + 1 = 10{\cdot}75} =$	·93 .	47·75 .	48·
2	$\dfrac{\text{D—11}}{\text{No.} + 1 = 5{\cdot}7} =$	1·93 .	23·50 .	23·7

I also enclose a method of finding the angular aperture by daylight. If it has not been published, and is worth insertion, perhaps you will find room for it also. It appears to me to have the advantage of being able to see clearly the extreme limits of distinct definition of the objective, although it is difficult to use with some objectives of low power, which do not give a sharp edge to the field of view. The method is by using the objective as a diminishing telescope, the eyeglass to be a common pocket or watchmaker's eye-lens, of two or three inches focal length, so placed behind the objective as to show distinctly a rule or a wall a few inches or more before it. The field of view will be the base of an angle, which appears equal to the angular aperture. To measure this angle, place the central point of the straight edge a graduated semicircle, exactly under the edge of the lowest combination of the objective, the convexity being towards the rule or wall. The number of degrees included between two lines drawn from that point to the extreme limits of the field of view, will be the measure of this angle.

The following table is, 1st, by this method; 2nd, after Mr. Pritchard, as described by Dr. Lardner; and, 3rd, as given by the maker. The adjustment ring in a line. I think that by the second method you by no means get the full angle with the two and one-inch.

Table of Angular Aperture of Objectives.

	1st.	2nd.	3rd.
$\frac{1}{8}$	128°	126°	125°
$\frac{1}{4}$	108°	105°	106°
$\frac{1}{2}$	58°	57°	60°
1	22°	16°	23°
2	16°	10°	15°

RICHARD NICHOLS, M.R.C.S.

ST. HELEN'S, JERSEY.

Micro-Stereographs.—In 'Quart. Journal of Micro. Science,' No. 3, for April, 1853, Professor Riddell gives the first announcement of a binocular microscope, and mentions its applicability for obtaining "match drawings" with the camera lucida, to be viewed with the stereoscope; and again, in No. 5, p. 24, for the same year, he says, "If the same object be drawn as seen, through each ocular respectively, a difference between the two drawings is perceptible, similar to that between match stereoscopic pictures; so that if these two drawings be viewed each with the appropriate eye, the natural relief of the object is reproduced."

In 'Trans.' of the Micro. Society ('Quart. Journal of Micro. Science'), No. 10, Jan., 1855, pp. 5, 6, in a paper on "Microscopic Photography," I described a method of obtaining micro-stereograms without shifting the object, simply by obscuring the alternate halves of the object-glass, by means of a sliding stop. I had before this abandoned the use of the camera, and given the preference to the image obtained through the shutter of a dark room, by means of a Heliostat; in fact, using the ordinary microscope as a solar one. This, besides other reasons, gives the very important one of allowing the light to be adjusted while the sensitive plate is in place (in an open frame) the instant before the impression is taken. With the arrangements employed, I may state it to be the most luxurious mode of taking photographs that I have practised—bath, developers, plates, &c., all being close to hand, so that there is no occasion to stir one step from your position. A pane of yellow glass is let into the shutter, above the microscope, to furnish light for manipulation. Also, during these experiments, I found that a pair of pictures, each taken with a right and left-handed illumination alone, was sufficient to bring an object up into relief in the stereoscope, particularly when objectives of large aperture were employed. As micro-photography and stereography are again the subject of attention, I allude to these circumstances, because they have either been lost sight of or revived as new facts.—F. H. WENHAM.

On the seat of the Colouring Matter in Flowers.—M. F. Hildebrand's observations* on the forms under which various colouring matters are found in flowers, and their distribution in the tissue of the several organs, warrant the following general conclusions:—(1) That the colour of flowers is in constant connection with the cell contents, never with the walls of cells. (2) *Blue, violet, rose,* and (if there be no yellow in the flower) *deep red,* are due, with little exception, to a cell-fluid of corresponding colour. (3) *Yellow, orange,* and *green,* are usually associated with solid granular or vesicular substances in the cells. (4) *Brown* or *gray,* and, in many cases, bright red and orange (apparently uniform to the unaided eye) are found to be compounded of other colours, as *yellow, green,* or *orange,* with *violet,* or *green* and *red;* bright red and orange in like manner of blue-red with yellow or orange. (5) *Black,* excepting in the Bean, is due to a very deeply-coloured cell-fluid. (6) All the cells of an organ are rarely uniformly coloured. (7) The colour usually resides in one or in a few of the outer layers of cells. (8) The coloured cells are but exceptionally covered by a layer of uncoloured ones. (9) Combinations of colour are occasioned by diversely-coloured matters in the same or in adjacent cells ('Nat. Hist. Rev.,' vol. ii, No. 8, p. 438).

Kelner's Orthoscopic Eyepiece.—Permit me to direct the attention of your readers to the new form of eyepiece lately brought out by Ross, 'Kelner's Orthoscopic.' The advantages which it possesses over the old Huyghenian eyepiece are

* Contained in Pringsheim's 'Jahrb.,' iii, p. 50.

a very much larger field, with more light, and yet without any sacrifice of defining quality. In using the lower powers of the microscope, it is often of much importance to have the whole of a large object in view, such as a section of coal, or wood, or a section of Echinus spine, &c., this the new eyepiece accomplishes most satisfactorily, and with a beautiful flat field. For more minute objects, when these consist of great diversity of forms, such as shells of Polycistina, or spicula of Gorgonia, or sponges, it is equally good, or better. These objects, shown by a one inch glass, and under the dark ground illumination, and viewed with the "C" Kelner's eyepiece, have thrown all to whom I have shown the sights into extacies; the almost illimitable view and the vast variety of objects strike the beholder with wonder; and the change that is effected when the old form of eyepiece is substituted, is very strikingly in favour of the new. It is also equally useful with the higher powers. Many of the larger and finest forms of Diatomaceæ cannot be all seen when shown by the highest powers, and a deep eyepiece of the old form; but, with the "Kelner," you may magnify an "Arachnoidiscus," until it appears like a dinner-plate in size, and yet be able to see the whole of the object. In conclusion, I may say that nearly all the microscopists to whom I have shown it have expressed their approval of its merits by procuring it for themselves.—Joseph Davison, Newcastle-on-Tyne.

PROCEEDINGS OF SOCIETIES.

MICROSCOPICAL SOCIETY, *October* 8*th*, 1862.

R. J. FARRANTS, Esq., *President*, in the Chair.

The following paper was read:—"On the Cleaning and Preparing of Diatoms," by J. A. Tulk, Esq.

November 12*th*, 1862.

R. J. FARRANTS, Esq., *President*, in the Chair.

Rev. Wm. Tyler, W. F. Graham, Esq., George Tyler, Esq., and Conrad Wm. Finzel, Esq., were balloted for, and duly elected members of the Society.

The following papers were read:—"On the Photographic Delineation of Microscopic Objects," by Dr. Maddox.

"On Acari produced in a Nitrate Bath," by the same.

December 10*th*, 1862.

R. J. FARRANTS, Esq., *President*, in the Chair.

Henry Davis, Esq., Wm. Revill, Esq., and Jno. T. Murray, Esq., were balloted for, and duly elected members of the Society.

A paper by Dr. Greville, "On some New Species of Diatomaceæ," was read.

LITERARY AND PHILOSOPHICAL SOCIETY, MANCHESTER.

MICROSCOPICAL SECTION.

October 20*th*, 1862.

Professor WILLIAMSON, F.R.S., *President of the Section*, in the Chair.

Mr. George Venables Vernon, F.R.A.S., was elected a member of the Section.

Mrs. Bury, of Croft Lodge, Ambleside, presented, through Professor Williamson, a series of twelve photographic plates, with seventy-two figures of *Polycistins* from drawings by that lady; also seventeen mounted slides of Barbadoes earth.

Mr. Horatio J. Frembly, of Gibraltar, presented, through Mr. H. A. Hurst, thirty-four slides of tongues of mollusca, collected and mounted by himself. An elaborate report upon their scientific classification was read by Dr. Thomas Alcock.

Mr. H. A. Hurst presented a collection of tongues of mollusca, from Bengal, made by him during his residence in India. They have been placed in the hands of Dr. Alcock, who has kindly undertaken to examine and report thereupon.

Captain J. C. Gales, of the ship "Quito," presented soundings taken off the coast of Chili and the Falkland Islands; two specimens of anchor mud, from the Falkland Islands; and some of the *Fucus natans* from the Sargossa Sea, with specimens of its inhabitants, dried in the sun. Captain Curling, of the P. and O. S. S. "China," presented four soundings from the coasts of Malabar, Yemen, Malacca, &c.; Captain Vickers, of the "Rosina Claypole," anchor mud from Port Royal and Black River, Jamaica, and a sounding taken off the south coast of Ireland; and Captain Samuel Flood, of the ship "Pantoleon," anchor mud from Sumatra and Malacca. Two deep Atlantic soundings in 1730 and 2220 fathoms, were also thankfully acknowledged.

Mr. Thomas Heelis presented many interesting specimens, collected during his late voyage, amongst which may be named two soundings from the Agulhas Bank, two specimens of Hoogly mud, scales of flying fish, and gulf weed, with minute crustacea and other animals preserved in spirits.

Mr. Joseph Sidebotham presented to every member of the Section a photographed finder for high powers, in case inscribed with the member's name.

Mr. John Dale presented a quantity of desiccated balsam dissolved in chloroform, to be divided amongst the members.

Mr. A. G. Latham presented a mounted spiracle of a mole cricket from Africa, and pointed out the difference from that found in this country.

Mr. E. W. Binney presented a copy of his paper "On some Fossil Plants showing structure, from the Lower Coal Measures of Lancashire."

A letter was read from Mr. Thomas D. Toase, of Jamaica, with reference to the animalcule previously described.

Mr. Brothers exhibited some fine specimens of *Stephanoceros*.

Mr. Parry exhibited some photographs of magnified sections of wood.

Mr. W. H. Heys exhibited the peculiar oil glands on the leaf of the *Procranthera violacea;* stellate hairs on the calyx of the *Deutzia scabra*, which differ from those on the leaves by having a greater number of rays and a central disc; spines of the *Loasa coccinea;* and two kinds of spangles upon oak leaves from Beddgelert.

Dr. William Roberts exhibited a mounted specimen of crystals of *Cystin*.

November 17th, 1862.

J. G. LYNDE, F.G.S., M. Inst. C.E., in the Chair.

Captain Randall, late of the barque "Brazil," forwarded eight soundings taken on the north coast of the Brazils.

Mr. Thos. Heelis presented a specimen of the *Echeneis Remora*, or sucking fish.

Mr. Parry presented a number of cells and rings in cardboard; they were very smooth, and sharply cut, without the bur usually produced by punching out cells. Mr. Parry explained that he had cut them in the lathe twenty or thirty together, the outside cuttings only presenting an appreciable bur.

Dr. Roberts called attention to the aid that might be received in the examination of the structure of animal and vegetable tissue by the use of colouring materials. Magenta is peculiarly adapted for this purpose, in consequence of its solubility in simple water and its inert chemical character. The nuclear structures of animal cells are deeply tinted by magenta, and by its use the nuclei of the pale blood-corpuscles, of pus-globules, of the renal and hepatic cells, of cancerous growths, and of all epithelial structures are brought out in great beauty, tinted of a bright carbuncle red. The *red* blood-disks are tinted of a faint rose-colour and a darker red speck, not hitherto noticed, is to be observed on the periphery of the corpuscle; it undergoes some changes when treated with tannin, and, subsequently, with caustic potash; but this point is still under investigation.

Dr. Roberts exhibited mounted specimens to illustrate his views.

Mr. John Leigh, M.R.C.S., exhibited a case of microscopical dissecting instruments, by Wood, of Manchester, which were highly approved of for completeness and finish.

Mr. Thos. H. Nevill exhibited, with dark ground illumination, some fine specimens of *Conochilus Volvox*.

ORIGINAL COMMUNICATIONS.

On our Present Knowledge *of the* Gregarinidæ, *with* Descriptions of three New Species *belonging to that class.* By E. Ray Lankester.

In Vol. I. of this Journal (1853), p. 211, an abstract appeared of some observations made by Kölliker and others on the Gregarinidæ, a group of animals of very simple structure, met with in the intestine and other parts of many insects and annelids, the nature of which was then, and is still, a matter of considerable interest to naturalists. Others have worked at the subject since that time, but little has been published in England relating to these parasites, nor are they generally known to microscopic observers in this country. It may, therefore, be advantageous to give in a condensed form what is known of their structure and development, adding a list of species and a few original observations.

In 1837, Léon Dufour* described a group of microscopic organisms, which he discovered in the interior of several species of insects, under the name of Gregarina, " qu'exprime l'habitude qu'ont ces Entozoaires de vivre par troupeaux." He had before remarked upon their occurrence,† but without fully describing or naming them. Here he describes them as possessing a mouth and composed of two membranes, the internal one enclosing a clear fluid. Later researches have shown Dufour's description to be partially erroneous. The Gregarinæ vary considerably in form, being, in most cases, more or less ovate. In those found in insects and crustacea the body is unequally divided by internal septa into two segments, which have been called respectively the anterior and posterior sacs. In some species three such divisions have been observed. Other forms met with in Annellida have no internal septa, but are unilocular. In

* 'Ann. des Sci. Nat.,' tome vii, 1837, p. 10.

† Ibid., tome viii, 1re séries, xiii.

some a sort of process projects from one end of the body, frequently provided with a circle of reflexed hooklets, which in the bilocular Gregarinæ is attached to the anterior sac. There is no appearance whatever of a mouth in these animals, and they appear to live by a process of absorption through the membranous envelope. Each sac contains in its interior a mass of granules varying in quantity, which by reflected light appear whitish and semi-opaque, but when viewed with transmitted light are seen to be transparent, and of a yellow colour. In the posterior sac a clear and well-defined vesicle is situated, which sometimes contains granules and a nucleus. The membrane of which the sacs are formed is transparent and contractile. In some species the existence of a second tunic within the posterior sac has been ascertained.

Dufour described six species of these parasites, all of which were bilocular.

Dr. Hammerschmidt, in the 'Isis von Oken,' 1838, followed up Dufour's observations, and named several new species, which he placed in four different genera—Clepsidrina, Rhizinia, Pyxinia, and Bullulina. There was, however, no ground for such a division, his genera being based upon the most trivial characters.

Dr. C. Th. v. Siebold also, in the 'Neueste Schriften,' Dantzig, 1829, described new species of Gregarinæ, which are given in the list below.

In 1845, Kölliker* described several unilocular forms of Gregarinæ, from the intestines of various Annelida. Between the publication of this first paper of Kölliker and his second, three German authors wrote, viz., J. Henle, in Müller's 'Archiv,' 1845, who described, for the first time, a species of Gregarina from the earthworm; A. von Frantzius ('Observationes quædam de Gregarinis,' Berolini, 1846), who, with Henle, questions the correctness of Kölliker's assertion, that the Gregarinæ are unicellular animals; and thirdly, Dr. F. Stein, in Müller's 'Archiv,' 1848, described various new species of Gregarinæ, and divided them into three families, of which mention will be made further on. Kölliker then published his second paper in the first volume of Siebold and Kölliker's 'Zeitschrift.' He enumerates thirty-five species of Gregarinæ, and enters at some length into their structure and affinities. The conclusions which he arrived at have before been quoted in these pages; it will be, therefore, only necessary to give them here briefly. 1st. The Gregarinæ are animals. 2ndly. They consist indubitably

* 'Zeitschrift für wissenschaftliche Botanik,' von M. T. Schleiden und C. Nageli, 2tes Heft, 1845.

of a single cell; their membrane corresponds to a cell-membrane; their contents to cell-contents; their vesicle to a nucleus; the granule or granules within it to a simple or broken up nucleolus. 3rdly. The Gregarinæ, which are constricted at the middle, also correspond most probably with a single cell of a peculiar kind. 4thly. There is no reason whatever for supposing that the Gregarinæ are not perfect animals. These four assertions have been questioned by various authors since that time. C. Bruch, in 'Sieb. and Köll.,' vol. ii, p. 110, opposed the last-mentioned assertion of Kölliker, and was inclined to regard the Gregarinæ as Filariæ in a quiescent state. Dr. F. Leydig, in Müller's 'Archiv' for 1851, brought forward what was apparently very strong evidence in favour of Bruch's theory, having seen the successive development of a simple quiescent Gregarina into an active vermiform creature, which he considered as a nematode. Kölliker, however, replied to this that he regarded the form described by Leydig as an Infusorium allied to Opalina or Proteus. It appears from the researches of M. Claparède and others, within the last few years, that some of the unilocular forms of Gregarinæ do present very curious, elongated, and active forms, which from their movements and general appearance might be mistaken for nematodes. Dr. Joseph Leidy has in the 'Transactions of the Philadelphia Society,'* denied the fact that the Gregarinæ are unicellular animals, upon the following grounds. In the examinations of some new species of Gregarinæ which he has described, and also in the *Gregarina Blattarum* of Siebold, he discovered that the membrane enclosing the granular mass of the posterior sac was double. He observes, "Within the parietal tunic of the posterior sac is a second membrane, which is transparent, colourless, and marked by a most beautiful set of exceedingly regular parallel longitudinal lines, which in *G. Juli marginati* measure the $\frac{1}{9375}$rd of an inch apart; in *G. Blattæ orientalis* the $\frac{1}{10,000}$th of an inch; and in *G. Passali cornuti* the $\frac{1}{15,000}$th of an inch. This tunic has entirely escaped the notice of all previous observers, and I can account for the circumstance in no other way than by supposing it has arisen from the inferiority of the microscope made by European continental artists. The lines or markings are easily observed without any other than the ordinary arrangements for light by $\frac{1}{4}$ of an inch, but better the $\frac{1}{12}$ of an inch, focal power of the instrument of Messrs. Powell and Lealand. Of course, if the existence of this second tunic be confirmed, and I have seen it too frequently and plainly to think I have

* 'Trans. of Phil. Society,' 1853.

been deceived, the idea of the Gregarina being a simple organic cell is at once exploded."

I have carefully examined the *Gregarina Blattarum* with Powell's $\frac{1}{4}$, and Smith and Beck's $\frac{1}{8}$, and have been able thus far to confirm Dr. Leidy's observations. In the intestine of the *Blatta orientalis* I met with the Gregarinæ in some numbers, presenting to the unassisted eye the appearance of semi-transparent whitish globules; when placed under the microscope and subjected to slight pressure the sacs appeared, containing but few granules, most having escaped through the rupture of the membrane. This was seen to be double, consisting of a transparent external tunic, through which the striæ on the internal coat were distinctly seen (fig. 20). This internal striped tunic appears not to extend to the anterior or cephalic sac, which is entirely without structure, and formed only by the external membrane.

The contents of the sacs were minute, ovoid granules, transparent, and presenting, *en masse,* a slightly yellowish colour. The anterior sac generally contains a less number of these granules; it is not contractile, as the posterior sac, and is more easily ruptured. This latter fact may be attributed to the absence of the striated tunic. In fig. 13, the striated appearance of the inner tunic is represented, the lines are nearly the $\frac{1}{10,000}$th of an inch apart. Figs. 9, 10, 11, are various forms of the *Gregarina Blattarum* which I have met with. In fig. 18, the nucleus is drawn as it appears when extruded from the posterior sac. Occasionally there are two such bodies lodged in the granular mass. The partition which divides the anterior from the posterior sac is structureless, and is probably an inversion of the external membrane. All communication between the anterior and posterior sacs is cut off by this membrane.

In the 'Mémoires de l'Académie Royale de Bruxelles' for the year 1854, an elaborate and beautiful paper, by M. Lieberkühn, copiously illustrated, appeared, describing his researches on the Gregarinæ of the earthworm. The author does not express any very decided opinion upon the two questions which have been discussed by Leidy and Bruch; but devotes the principal part of his memoir to the development and reproduction of the Gregarinæ. He, however, mentions that he has seen longitudinal striations on the membrane of some forms, and figures them, but is uncertain as to whether they are structural, or due only to contraction. With regard to the development of Gregarinæ into filaria-like worms, which Bruch, who made his observations chiefly on the *Gregarina Lumbrici,* thought probable, M. Lieberkühn says but little, but, nevertheless, has proved beyond doubt that the nematodes of the earthworm are developed from eggs, whence they emerge, not as Gregarinæ, but as true nematodes. The transformation of two Gregarinæ, after a process of encystation, into navicula-like bodies, has already been described by Bruch; but Lieberkühn has more fully illustrated the changes which go on, and has endeavoured to trace the existence of the Pseudo-naviculæ after they have been expelled from the cyst. In the perivisceral cavity of the earthworm he found large numbers of small corpuscles, exhibiting Amœba-like movements and likewise Pseudo-naviculæ, containing granules, formed from encysted Gregarinæ. He imagines that these latter bodies burst, and that their contained granules develope into the Amœbiform bodies which subsequently become Gregarinæ. In the same year * M. Lieberkühn published another paper, describing his further researches among the psorosperms of fish, in which he adopts the same view, that the Amœbiform corpuscles of the blood of fish are Gregarinæ. Few physiologists will feel disposed to agree with M. Lieberkühn, in considering these bodies as parasites. Dr. Williams, of Swansea,† has described a great variety of forms, from Mollusca, Crustacea, and Annelida, remarking that they are characteristic of the fluids of invertebrata. M. Milne Edwards, in his 'Leçon sur Physiologie,' speaking of the white corpuscles of the blood, makes the following remarks upon Lieberkühn's proposition:—"Enfin M. Lieberkühn qui vient de faire une étude attentive de ces corps, croit même de voir les considérer comme étant des animalcules parasites et les assimiler aux Amibes, petits infusoires dont l'intestin de divers animaux est parfois infesté; mais les arguments en faveur de cet opinion ne me paraissent pas assez solides, pourque dans l'état de la science, on puisse l'adopter; et lors même que quelques uns de ces corps seraient réellement de la nature des animaux sarcodaires, il ne faudrait pas conclure que tous les corpuscles incolores et granules du sang sont des parasites, car il parait evident, comme nous le verrons par suite, que ce sont en générale, bien réellement des produits de l'organisme" (pp. 73, 74, vol. i). Also further on, in speaking of these "corpuscles de plasme" in invertebrata, he adds, "Ce phénomène remarquable a été fort bien observé par M. Wharton Jones, aussi que par M. Williams, et par quelques autres physiologistes * * * * et il est si frequent ici que je ne saurais l'attribuer à l'existence d'Amibes parasites comme le fait M. Lieberkühn" (p. 103, vol. i). The

* Müller's 'Archiv,' 1854.
† 'Proc. Royal Soc.,' 1852.

Amœbiform bodies, then, described by Lieberkühn cannot be considered as the young stage of the Gregarina. It is possible, however, as M. Milne Edwards has observed, that *some* of these bodies, which are hardly distinguishable from the true plasmic corpuscles, are developed from the Pseudo-naviculæ. I have made careful examination of more than a hundred worms for the purpose of studying these questions, but have succeeded in arriving at no other conclusion than that certain forms of these corpuscles may be the products of encysted Gregarinæ. The *Gregarina Lumbrici* (fig. 25) is one of those forms which are unilocular, and are met with most frequently among Annelids. It consists of a transparent contractile sac (which has not hitherto been demonstrated to be formed by more than a single membrane), enclosing the characteristic granules and vesicle. The vesicle is not always very distinct, and is sometimes altogether absent; occasionally it contains no granules, sometimes several, one of which is generally nucleated (figs. 25, 26). The average length is $\frac{1}{180}$th of an inch. Many varieties are met with in the Lumbricus, but there appears to be no reason for considering them as distinct species. In figs. 26, 27, a rather uncommon form is drawn. It is much smaller than that drawn in fig. 25, measuring from $\frac{1}{800}$th to $\frac{1}{300}$th of an inch in length, and is provided with a number of motionless filaments; there are few granules in the interior, but one of them is always nucleated. Another form (fig. 28), which I have only met with twice, contains the vesicle and granules, and is further surrounded by a number of conical bodies which seem to form a sort of envelope enclosing it. Lieberkühn, who has seen both these forms, calls them "Gregarines velues," and has observed them in the act of casting off this remarkable covering. Frequently in the examination of the testis of the Lumbricus, two Gregarinæ of the larger, well-developed form may be seen enclosed in a transparent cyst, varying in size from the $\frac{4}{1000}$th to $\frac{1}{100}$th of an inch in diameter (fig. 21). Occasionally a single individual appears in this condition. In some of these cysts a number of nucleated cells may be seen developing from the enclosed Gregarinæ, which gradually become fused together and broken up, until the entire mass is converted into these nucleated bodies, which are then evident in different stages of development, (figs. 22, 23), assuming the form of a double cone, like that presented by some species of Diatomaceæ, whence their name Pseudo-naviculæ. At length the cyst contains nothing but Pseudo-naviculæ, sometimes enclosing granules, which gradually disappear (fig. 24). Finally the cyst bursts.

This fact was denied by Stein,* who affirmed that the cysts burst only upon being subjected to the action of water. Lieberkühn has, however, proved this statement to be erroneous, having kept cysts taken from Lumbricus in water for the space of five days, without any apparent change taking place in their form or size. I have frequently seen agglomerations of the Pseudo-naviculæ evidently in the same position as they were when contained in the cyst, which had itself entirely disappeared, probably by decomposition. On escaping from the cyst, the Pseudo-naviculæ contain no granules (fig. 32); but the gelatinous fluid which they enclose appears to concentrate itself, and give rise to certain minute bodies, which, collecting towards the centre, form a nucleus-like mass. A change then comes upon the form of the Pseudo-navicula (figs. 29—31); it loses its symmetry, and becomes flaccid; the external membrane becomes atrophied (fig. 31), "commence a s'atrophier," and assumes an irregular shape. I have not been able to trace the changes which these curious bodies undergo any further. M. Lieberkühn, as remarked above, considers that the granules which they enclose are liberated, and become the Amœlea-like bodies found in the perivisceral fluid. In a note at the end of his memoir, M. Lieberkühn modifies his views with regard to the nature of the corpuscles, and allows that they may, perhaps, be analogous to those found in the perivisceral fluid of the naïads; but still maintains that, at any rate, some of these bodies are young Gregarina, an opinion in which my own observations lead me to concur.

I have made repeated examinations of the *Gregarina Blattarum,* in the hope that facts might be gained thence which would throw additional light on the subject. Encystation seems to take place much more rarely among the bilocular forms of Gregarina than in the unilocular species found in the earthworm and other Annelids. In fig. 17, a cyst is represented enclosing two of the *Gregarina Blattarum;* this is the only instance of the kind which I have met with in the Blatta. Stein figures certain bodies from the *Blatta orientalis,* which he calls the Pseudo-naviculæ of *G. Blattarum.* I have not met with these forms in my examination of the species. The blood-corpuscles of the insect itself have an appearance very similar to that which Stein figures. In fig. 14 are represented three very minute forms, which are not uncommon in the intestine of Blatta. They measure respectively the $\frac{1}{2000}$th, $\frac{1}{1500}$th, and $\frac{1}{1000}$th of an inch in length, and, perhaps, may be the young of the Gregarina.

* Müller's 'Archiv,' 1845.

The smallest of them is merely a cell containing granules and a nucleus. In the second a septum is seen dividing the cell into two halves. The third form has all the appearance of a true Gregarina in a very young stage. Leidy has seen such bodies in the intestine of Julus.

M. Ed. Claparède, in his 'Recherches Anatomiques sur les Annelides, Turbellaries,' &c., describes several new forms of Gregarina from three species of Annelida. The most interesting of these is from the intestine of *Capitella capitata*. It is unilocular, contains granules and a vesicle, and has the form of an anchor; its length is ·35 mm. This species appears to have been seen by Leuckart, who named it *G. sagittata*.* In the intestine of a Phyllodoce, M. Claparède frequently met with a species of Gregarina, striated longitudinally, somewhat fusiform in shape, and very active; its length was ·41 mm. Some of these organisms contained Pseudo-naviculæ; other smaller forms were abundant, which were not striated—probably the young of the preceding. In the intestine of *Pachydrillus semifuscus* another species was found; very minute, containing granules and a vesicle: its average length was ·05 mm. M. Claparède does not name these last two species, but in the catalogue below I have given them specific names, in order to complete the list.

In the intestine of *Serpula contortuplicata* I have met with a species of Gregarina in some numbers (figs. 4—7). In its general form it approaches the species described by M. Claparède from the intestine of Phyllodoce; it is striated longitudinally, contains a vesicle and very minute granules. The average length is $\frac{1}{200}$th inch; its movements are slow but constant; in some specimens there was an anterior prolongation of the sac-membrane, which, however, was not persistent. I have given the specific name "*Serpulæ*" to this species, as I believe it has not before been described.

In the intestine of *Aphrodite aculeata* I have found an elongated, fusiform Gregarina, of large size (figs. 1—3), containing numerous granules and a clear vesicle. It measured $\frac{1}{25}$ inch in length, and was provided with an elongated appendage one third the length of the body, the extremity of which was involuted and terminated by a circular protuberance. This is the only unilocular form of Gregarina which at present has been found provided with a proboscis; it is interesting, too, inasmuch as the existence of two membranes composing the sac is evident. The external one envelopes the whole animal, and forms the involutions at the extremity

* Wiegman's 'Archiv,' 1861, Bericht, &c., for 1859.

of the proboscis (fig. 2 *a*). Within this the second membrane can be plainly observed, enclosing the granular mass, and extending within the proboscidiform appendage, but not involuted as is the external membrane (fig. 2 *b*). In some varieties this second tunic is still more evident, being contracted within the external membrane, and exhibiting striations (fig. 3). In the list appended to this paper, I have named this species after the annelid which it inhabits.

In various species of Sabella, I have met with many unilocular Gregarinidæ of an elongated form, measuring from $\frac{7}{1000}$th to $\frac{9}{1000}$th of an inch in length (fig. 15, 16). This species, which I propose to call *Monocystis Sabellæ*, differs considerably from that found in Serpulæ, being much longer in proportion to its breadth, and attenuated at one extremity. There are but few granules in the sac, and very indistinct striations on the surface; a well-defined vesicle, generally without any contents, is always present. The species of Sabella I examined were *S. alveolata*, (Amphitrite) *bombyx*, *inpendiculum*; but the Gregarinæ appear to belong to one species, and present no difference in structure or form.

On account of the great mutability of form which is characteristic of the Gregarinæ, the attempt to divide them into families, genera, and even species, is attended with considerable difficulty. In 1838,* Dr. Hammerschmidt placed certain new forms of Gregarina in four genera, Clepsidrina, Rhizinia, Pyxinia, and Bullulina, scarcely assigning his reasons for so doing. Kölliker did not make any division of the species he described, but left them all in Dufour's genus Gregarina. In 1845, Dr. F. Stein, believing Hammerschmidt's genera to be entirely unsatisfactory, proposed the following classification of the species then known, dividing them into three families and seven genera, thus:

Family. Monocystideæ; unilocular Gregarinæ.
- *Genus.* Monocystis; animals living singly.
- *Genus.* Zygocystis; animals living in pairs.

Family. Gregarinariæ; body divided into two portions by a septum.
- *Genus.* Sporadina; single animals, without an appendage to the head.
- *Genus.* Stylorhynchus; single animals, with a proboscidiform appendage to the head.
- *Genus.* Actinocephalus; single animals, with an appendage to the head, furnished with hooks.

* 'Isis von Oken,' 1838, p. 356.

Genus. Gregarina; two animals frequently hanging together.

Family. Didymophyideæ; body divided into three parts by two septa.

Genus. Didymophyes; characters of the family.

Of this classification Professor Greene* remarks—"This, however, is an arbitrary division, and if not erroneous, is certainly premature." Certain of the genera proposed by Stein are, without doubt, objectionable; thus, the genus Zygocistis is based upon a habit of the species, namely, that of adhering together, which is only occasional, and is common to all Gregarinæ when about to become encysted. The fact of certain Gregarinæ being provided with anterior appendages is not sufficient to constitute a genus, inasmuch as certain species which usually present the characters of the genus Sporadina have occasionally been found with a well-developed appendix to the cephalic sac.† Similar objections may be raised against the genera Actinocephalus and Gregarina. Dr. C. M. Diesing, in his 'Systema Helminthum,'‡ has given a complete list of species known at that time, with descriptions of some new species from Crustacea, and has supplemented this by a further catalogue of species in the 'Sitzungsberichte der Academie der Wissenschaften,' 1859. The existence of a double membrane, and its peculiar modification into a prehensile or absorbent organ, certainly does appear to raise certain Gregarinæ above the Protozoa; their true position in the scale of nature is by no means yet satisfactorily decided. He places the Gregarinidæ among the *Helmintha rhyngodea*, considering the proboscidiform appendage with which some Gregarinæ are furnished, as a suctorial apparatus. He enumerates seventy-five species, but many of these require further investigation before they can be admitted as distinct from other forms with which they are associated. Dr. A. Schmidt, in 'Abhandl. d. Senkenberg'schen Gesellschaft,' i, 1854, has described several varieties of Gregarinæ from the earthworm. Schultze, Œrsted, and others have described species of Gregarinæ; reference to their works will be found in the bibliography at the end of this paper. In the following list of species I have modified Stein's classification, and suppressed some of the species which appear to be mere varieties. I have also given the names under which the species were originally described, Diesing having attempted to alter them consider-

* 'Manual of the Protozoa,' p. 51.

† Leidy, loc. cit.

‡ Vol. ii, p. 6, &c., Vindobonæ, 1851.

ably, without assigning any justification of such a procedure. There appears to be no reasonable ground for objecting to the separation of the unilocular forms from the rest of the Gregarinæ. In addition to the absence of any septa dividing them into distinct chambers, they differ so much from the other Gregarinæ in their general form and habit, that there is, it will be allowed, sufficient pretext for placing them provisionally in a distinct genus.

RHYNGODEA HELMINTHA. Diesing.

Protozoa symphyta, Stein.

Animals composed of a double membrane, enclosing minute granules and a vesicle; frequently provided with a prehensile or suctorial (?) appendage.

Genus, MONOCYSTIS, Stein. Unilocular.

SYN. *Gregarina,* Kölliker, Diesing, &c.
Zygocystis in part, Stein.

1. *M. Lumbrici,* Henle and Lieberkühn. *Lumbricus.*

SYN. *Zygocystis cometa,* Stein.
Monocystis agilis, Stein.
„ *cristata,* Schmidt.
„ *magna,* Schmidt.
„ *nematoides,* Schmidt.
„ *porrecta,* Schmidt.
„ *Lumbrici olidi,* Schmidt.
Gregarina Lumbrici, Bruch.

2. *M. Sipunculi,* Kölliker. Sipunculus.

SYN. *Zygocystis Sipunculi,* Stein.

3. *M. Holothuriæ,* Schneider. Holothuria.
4. *M. Sænuridis,* Köll. Sænuris.

SYN. *Zygocystis Sænuridis,* Stein.

5. *M. Enchytræi,* Köll. Enchytræus.
6. *M. Spionis,* Köll. Spio.
7. *M. Terebellæ,* Köll. Terebella.
8. *M. Nemertis,* Köll. Nemertis.
9. *M. Planariæ,* Schultze. Planaria.
10. *M. Pachydrilli,* Claparède. Pachydrillus.
11. *M. Phyllodocæ,* Claparède. Phyllodoce.
12. *M. pellucida,* Köll. Nereis.

SYN. *Greg. Nereidis,* Leidy.

13. *M. Serpulæ,* Lankester. Serpula.

14. *M. Aphroditæ*, Lankester. Aphrodite.
15. *M. sagittata*, Leuckart. Capitella.
16. *M. Clavellinæ*, Köll. Clavellina.
17. *M. Sepiæ*, Lieberkühn. Sepia.
18. *M. Euaxis*, Menge. Euaxis.
19. *M. putanea* (?), Lachmann. Gammarus.
20. *M. Sabellæ*, Lankester. Sabella.

Genus, GREGARINA, Dufour, Bilocular.

SYN. *Clepsidrina*, *Rhizinia*, *Pyxinia*, *Bullulina*, Hammerschmidt.
Sporadina, *Actinocephalus*, *Stylorhynchus*, *Didymophyes*, Stein.

1. *G. curvata*, Hammerschmidt. Cetonia.
2. *G. clavata*, Köll. Ephemera.
   SYN. *Zygocystis Ephemeræ*, V. Frantzius.
3. *G. Dytiscorum*, V. Frant. Dytiscus.
4. *G. Reduvii*, Stein. Reduvius.
5. *G. Juli*, V. Frantz. Tulus.
   SYN. *G. Juli pusilli*, Leidy.
   G. Juli marginati, Leidy.
   G. larvata, Diesing.
6. *G. Scolopendræ*, Köll. Scolopendra.
7. *G. ovata*, Dufour. Gryllus, &c.
8. *G. sphærulosa*, Dufour. Ædipoda and Gryllotalpa.
9. *G. soror*, Dufour. Phymata.
10. *G. ovata*, Dufour. Gryllus, Forficula.
11. *G. hyalocephala*, Dufour. Tridactylus.
12. *G. oblonga*, Dufour. Gryllus.
13. *G. Amaræ*, Hammerschmidt. Amara.
14. *G. tenuis*, Hamm. Allecula.
15. *G. Tipulæ*, Hamm. Tipula.
16. *G. elongata*, V. Frantz. Crypticus.
17. *G. Mystacidarum*, V. Frantz. Mystacida.
18. *G. Polydesmi*, Leidy. Polydesmus.
19. *G. Passali*, Leidy. Passalus.
20. *G. Achetæ*, Leidy. Acheta.
   SYN. *G. oviceps*, Diesing.
21. *G. Scarabæi*, Leidy. Scarabæus.
22. *G. Melolonthæ*, Leidy. Melolontha.
23. *G. Psocorum*, V. Siebold. Psocus.
24. *G. Blattarum*, V. Siebold. Blatta.
   SYN. *G. Blattæ*, Leidy.
25. *G. caudata*, V. Siebold. Sciara.
26. *G. Locustæ*, Leidy. Locusta.
   SYN. *G. fimbriata*, Diesing.

27. *G. conica,* Dufour. Coleoptera and Gryllus.
28. *G. rubecula,* Hammerschmidt. Dermestes.
29. *G. acus,* Stein. Carabus.
30. *G. oligacantha,* V. Siebold. Agrion.

    SYN. *G. Sieboldii,* Köll.

31. *G. Lucani,* Stein. Lucanus.

    SYN. *G. obesa,* Diesing.

32. *G. longicollis,* Stein. Blaps.

    SYN. *G. Mortisagæ,* Diesing.

33. *G. Heerii,* Köll. Phryganea.

    SYN. *Stylorhynchus octacanthus,* Frantz.
    G. Frantziusiana, Diesing.

34. *G. polymorpha,* Hammerschmidt. Tenebrio.

    SYN. *Stylorhynchus ovalis,* Stein.
    G. cuneata, Stein.

35. *G. Phallusiæ,* Köll. Phallusia.
36. *G. Balani,* Köll. Balanus.
37. *G. longissima,* v. Siebold. Gammarus.

    SYN. (?) *G. diffluens,* Diesing.
    G. milliaria, Diesing.
    (*Actinocephalus*) Stein.
    G. putanea, Leuckart.
    G. Gammari, V. Siebold.
    (*Didymophyes*), Stein.

38. *G. conformis,* Diesing. Cancer.
39. *G. præmorsa,* Diesing. Platycarcinus.
40. *G. paradoxa,* Stein. Geotrupes.

    SYN. *G. echinorhynchus,* Diesing.
    Echinorhynchus, Stein.

41. *G. brevirostris,* Köll. Hydrophilus.
42. *G. gigantea,* Stein. Oryctes.

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Reference may also be made to Greene's 'Manual of Protozoa,' p. 51 ; 'Carpenter's Microscope' (2nd edition), p. 464 ; Pritchard's 'Infusoria' (last edition), p. 262 ; Micrographical Dictionary, article, "Gregarina."

On the Anatomy *of* Nerve-fibres *and* Cells, *and the* Ultimate Distribution *of* Nerve-fibres. Three Demonstrations delivered by Professor Lionel S. Beale, M.B., F.R.S., at King's College, on January 16th, 23rd, and 30th, 1863. Abstract and Remarks by G. V. Ciaccio, M.D., of Naples.

Professor Beale has been giving, in connection with his course of Physiology at King's College, several demonstrations 'On the Practical Use of the Microscope, and the Structure of the Simple Tissues of the Human Body.' In each lecture eleven microscopical specimens magnified from 20 to 700 diameters, and illustrative of the subject of the lecture, have been passed round a class of nearly one hundred students and medical gentlemen, and many most difficult points relating to this very important branch of study have been demonstrated and studiously discussed. We propose to give a short account of the specimens illustrating three of the most interesting of these demonstrations on the structure of nerves and ganglia, and on the origin and termination of nerve-fibres. Although we believe that many of the readers of the 'Microscopical Journal' are well acquainted with Dr. Beale's researches on the general anatomy of tissues, and his views upon structure and growth, it seems to us to be necessary, before proceeding to the description of the specimens, to give a brief sketch of his views on the hystology of the nervous system, which have resulted from other observations made during the last three years.

Dr. Beale holds strongly to the opinion that the nerves, in every case, are continuous in the nervous centres, with the substance of the nerve or ganglion-cells, and, at the periphery, with other small masses of germinal matter, commonly termed nuclei. He maintains that there are no true ends to be demonstrated, and that nerves never shade off into or become continuous with other tissues. Although often in very close relation with the elements of other textures, the nervous still exists as a distinct tissue. The nuclei or corpuscles above referred to are found in connection with all nerves at their peripheral distribution. They are generally oval, although they may sometimes exhibit the triangular or other form, and they always constitute an essential part of the nerves. Their number varies greatly, not only in the nerves, which are distributed to the different parts of the same animal, but also in the nerves distributed to similar parts in different animals. Besides, the nuclei are found more numerously in the nerves at an early period of development than in the fully developed nerves. For instance, the nerves distributed to the leg muscles of the frog contain fewer nuclei than those which are distributed to the muscles of the eye, tongue, or heart of the same animal. Again, the nuclei contained in the nerves distributed to the thigh muscles are far more numerous in mammalia, especially in the mouse, than in the frog. The general conclusion which may be drawn from these facts is, that the nuclei connected with the nerve-fibres at the periphery are the special organs upon which depend the growth and multiplication of the fibres, and most probably, through their influence, the nerves are brought into relation with the different tissues of the body. It may be also inferred that, when a tissue is supplied with numerous nuclei, its importance as a structure or apparatus concerned in nervous action must be very great.

As Dr. Beale, by a careful examination of a great many specimens, has never been able to find an end to the nerve-fibres, either at their peripheric distribution or at their implantation into nervous centres, he is strongly of the opinion that the fibres proceeding from a central nerve-cell return to the same cell, after a course more or less circuitous and tortuous. They may be connected during their course with other cells and fibres, but the circuit which they form is considered by Dr. Beale to be complete; so that every nerve or ganglion-cell with the fibres which proceed from it establishes and forms a nervous circuit. This circuit, however, is not independent, but always in relation with the circuits formed by the other cells. According to this view, it is very probable that all nervous phenomena, either of motion or sensation, are associated with the setting free of electric or of some other current allied to it, and its conduction to distant parts above the fibres. Chemical and physical changes which take place in the germinal matter of the nerve or ganglion-cells at the centre or periphery lead to the production of the currents. The supposed currents must always originate in, and start from, the germinal matter alone;—the nerve-fibres being, as agreed by all observers, mere conducting fibres.

Dr. Beale's views on the anatomy of nerve-structures and organs and their action are opposed to the conclusions of most of the German observers. And if their statements respecting the existence of a polar or unipolar cells, and the free termination of nerves, could have been proved true, Dr.

Beale's views would not be tenable. But, Dr. Beale states, that after very numerous observations upon the ganglia of man and animals, especially those of the frogs, he is compelled to conclude that neither apolar nor unipolar cells exist anywhere, and that nerves never terminate in free ends in any tissues.

All nerve or ganglion-cells are bipolar or multipolar. The existence of cells with only one fibre is very doubtful, even in the case of very young cells, for what seems to be only a single fibre under a power of 250 or 300 diameters, is found to be composed of two or more fibres when the highest powers are used. Dr. Beale, in many cases in which, at the first appearance, the ganglion-cells seemed to be without any fibre whatever, has been able to show several springing from different parts of them. He has also demonstrated that the so-called Remak's fibres are true nerve-fibres; and in affirming this he differs from most observers in the present day; for it is generally held that this kind of fibre is nothing else than a modified form of connective tissue, an extension of which is supposed to form the capsule of the ganglion-cell. These fibres, as is shown in his specimens, contain a great number of nuclei, and are continuous with the outer part of the germinal matter of the ganglion-cell.

With regard to the termination of the nerves in voluntary muscles, and especially in those of the mouse, Dr. Beale has given the results of his investigations in a very valuable paper read before the Royal Society in June, 1860. The conclusions which he arrived at are as follows:

1st. That every elementary fibre of the striped musle of the mouse is more or less abundantly supplied with nerves.

2nd. That the nerves terminate in a network outside the sarcolemma.

3rd. That the nerve-fibres which form this network are pale fibres abundantly nucleated. They cross the muscular fibre at short intervals in every part, and often at right angles.

4th. That these pale fibre are directly continuous with the dark-bordered fibres.

Since the publication of Dr. Beale's paper, Kühne and Kölliker have studied the subject, and the conclusions which they have arrived at are quite inconsistent with those of Dr. Beale.

Kühne states that he has observed the thin breast muscle of the frog, and found that the pale nerve-fibre, at one point, penetrates the muscular fibre, and divides beneath the sarcolemma into two or more fine fibres, which terminate in peculiar oval bodies, considered by him as special organs. He further says that, in the muscles of the leg of *Hydrophilus piceus,* the axis cylinder, after passing through the sarcolemma, is lost amongst granular matter, but is probably connected with the rows of granules, or nuclei, which extend throughout the length of each elementary muscular fibre. Through these nuclei it comes into close relation with the sarcous substance of the fibre.

Kölliker, on the other hand, after examining the same muscle of the breast of the frog, has arrived at a different conclusion. He quite failed to see the special oval bodies as described by Kühne, but saw the nuclei connected with the fibres; and he states that the nerve-fibres never pass through the sarcolemma, but always lie outside it. So, far, therefore, he agrees with Dr. Beale, but differs from him in asserting that the nerves end in *free* extremities.

It was indispensably requisite for Dr. Beale, after these statements of Kühne and Kölliker, to study this same muscle. The results of his observations were given in a memoir read before the Royal Society on June 19th, 1862. According to his observations the ultimate arrangement of the nerves in the pectoral and other muscles of the frog is fundamentally the same as that in the muscles of the mouse, the only difference being that the nerves in the frog are thinner, firmer, and much less numerous than in the mouse. They form a network outside the sarcolemma, the meshes of which are very wide. The various nerve-fibres of this network are very fine, and the nuclei are much less numerous than those of the mouse; they are directly continuous with the dark-bordered fibres, and result from their division and subdivision; but there are also to be traced some very fine fibres derived from fine fibres ramifying in the sheath of the dark-bordered fibres which have not previously been described by any observer. He was also enabled to follow the fibres much further from the point where Kühne and Kölliker make them to end; the former in the special oval bodies, and the latter in free extremities. It may also be added that the finest nerve-fibres seen by him in the breast-muscle of the frog are often not more than one third of the width of the pale fibres of Kühne beneath the sarcolemma; and even these fine fibres are not single, but consist of at least two fibres. By a careful examination of the ultimate distribution of the nerves to the muscles of the leg of *Hydrophilus piceus,* he came to the conclusion that the rows of nuclei described and figured by Kühne as belonging to the nerve-fibres, are the proper nuclei of the muscular fibre itself. In this insect, as is shown by a transverse section of the muscular fibre, the nuclei are seated in the substance of the contractile substance. The nerve-fibres do not penetrate through the sarcolemma, but always lie on the surface, where they divide and subdivide, forming networks of very fine fibres, many of which (although much finer than the fibres delineated by Kühne in his drawings) can be traced over several elementary muscular-fibres. It is most unsatisfactory, and, at the same time, surprising to find that these three authorities in microscopical anatomy have been led by studying the same object to conclusions so incompatible with each other. This, however, occurs not unfrequently in all investigations of natural things, and we believe that it arises from two causes. The first, that the minds of individuals are differently constituted, so that when two observers investigate one object they do not view it in the same manner; the second, that the same object prepared in various ways exhibits under microscopical examination different appearances. To the latter, rather than to the former cause, we are inclined to ascribe the different conclusions arrived at in the present instance; and we believe that had the observers examined one object always under the same conditions we should not have to complain of so many terrible discrepancies which at present complicate histology. It is of great importance in microscopical investigations to prepare the object in such a way, that while we are endeavouring to find out the structure and render the appearances distinct, so as to demonstrate them to others, we should preserve, as far as possible, their natural appearances. With regard to the examination of the ultimate arrangement of nerves in different parts of the body, we think that Dr. Beale's method of preparing is one of the best, for it alters, as little as possible, the delicate structure of nerves at their termination. We have had many opportunities of using this method, and always with great success. We, therefore, highly recommend it to those who are engaged in this kind of research; and it should be borne in mind that in preparing all the tissues of vertebrate animals, Dr. Beale employs the same method. Not only so, but the appearances described by him in many of the lower plants and animals, were observed in specimens prepared by the same general plan.

We shall now proceed to describe briefly the principal and most interesting specimens which were sent round during the lectures. Every specimen has been carefully examined by us, and we feel convinced that the description given is supported by irrefragable facts.

Prep. 1.—Bundle of pale, gray, or gelatinous fibres with ganglion-cells, from the pericardium of the ox. Each ganglion-cell is seen to be connected with several fibres. The bundle does not contain any nerve-fibre with the white substance of Schwann. The specimen shows evidently that the so-called Remak's fibres are true nerve-fibres, and the structure, which has been described as the connective tissue capsule of the ganglion-cell, consists only of true nerve-fibres. If we accept the opinion entertained by some German observers, that Remak's fibres are nothing but fibres of connective tissue, we are compelled to admit that there are ganglion-cells imbedded in connective tissue with no connection whatever with nerve-fibres. In which case the physiological significance of these cells would be inexplicable. × 215.

Prep. 2.—Large ganglion with several cells form the cord of the leech. Some of the cells are larger than others. Bundles of fibres are seen proceeding from the ganglion in six different directions. Some fibres, which spring from its upper and lower part, are observed in connection with those which arise from the sides. Some other fibres pass downwards through the ganglion without being connected with it. The ganglion is seen to be composed of several parcels of cells which are connected together by strands of fibres. The connections between the different cells are very numerous. × 215.

Prep. 3 and 4.—Are two beautiful specimens which plainly show the origin of two fibres from the so-called unipolar ganglion-cells from the frog. The finest of the nucleated fibres is seen passing spirally round the other. This arrangement has not been previously described. Dr. Beale is engaged upon a memoir on this subject. × 215, 500.

Prep. 5.—Shows several ganglion-cells, each of which is connected with a dark-bordered fibre. The second very fine fibre is not visible in this specimen. From the posterior root of spinal nerves of a frog. × 180.

Prep. 6.—Very large ganglion from the posterior root of spinal nerves of the mouse. The nerve-fibres of the anterior and posterior root pass through the ganglion and mix together. Every cell is seen to be connected with many fibres which pass off in different directions. × 40.

Prep. 7.—Two ganglion-cells with nerve-fibres from the superior cervical ganglion of the sympathetic of man. The nerve-fibres connected with these ganglion-cells are seen largely supplied with nuclei. × 215.

Prep. 8.—A very small ganglion from the tongue of a mouse. It appears to be composed of about twelve cells. Nucleated nerve-fibres proceed from the ganglion in four different directions. × 700.

Prep. 9.—Shows bundles of nerve-fibres connected with ganglion-cells near the origin of the aorta. From man. × 130.

Prep. 10.—Large ganglion-cells, from each of which two fibres proceed, with bundles of nerve-fibres near the iliac artery of a frog. Some fibres are seen passing over the artery. × 130.

Prep. 11.—Iliac artery, with nerves and ganglion-cells in its outer coat. From the frog. Some very fine nerve-fibres are seen ramifying in the muscular coat of the artery. 215.

Prep. 12.—This beautiful specimen shows arteries, pigment-cells, nerves, and ganglia near the kidney. The different nerve-fibres arising from the ganglion-cells are seen to contain numerous nuclei. × 215.

Prep. 13.—Some nerve-fibres from the pig's snout, showing individual tubular nerve-fibres, separated from their neurilemma. Some fibres much finer than others. The medullary sheath of the nerve-fibres is clearly visible. × 40.

Prep. 14.—Some other individual nerve-fibres from the same animal. The specimen most distinctly demonstrates the white substance, the axis cylinder, and the nuclei of the primitive nerve-fibres. Some of the nuclei, which at first seem to belong to the so-called tubular membrane, after a more accurate examination, are undoubtedly proved to be the proper nuclei of fine nerve-fibres ramifying in the sheath. × 130.

Prep. 15.—A bundle of very fine nerve-fibres imbedded in connective tissue of frog. × 130.

Prep. 16.—Is a section through a large nerve of pig's snout, and demonstrates that nerve-trunks are made up of several bundles of nerve-fibres joined together by connective tissue; the nerve-fibres forming a bundle, and the various bundles also are of different sizes. The neurilemma and the capillary vessels for the nutrition of the nerve are distinctly seen in this specimen. × 40.

Prep. 17.—Median nerve of a fœtus at the sixth month. Capillaries injected with carmine solution. Numerous nuclei are seen in connection with the dark-bordered fibres, and many vessels also, running over and amongst the connective tissue of the nerve. This specimen proves that the nuclei and vessels are more numerous in nerve-tissue during the development than when the development has been completed, as is the case in all tissues of all animals. × 215.

Prep. 18.—Bundles of very fine dark-bordered fibres from the submucous tissue of the palate of a frog. The bundles, after dividing and subdividing, form a network, the fibres of which are compound, and are themselves composed of numerous very fine fibres. Vessels injected with Prussian blue. × 215.

Prep. 19.—Shows the manner in which the dark-bordered nerve-fibres branch on the surface of the elementary fibres of muscles. Some fibres are seen dividing dichotomously, and others into three or four branches. × 215.

Prep. 20.—A Pacinian corpuscle from the mesentery of a cat, showing the pale nerve-fibre at the centre. × 130.

Prep. 21.—Small piece of the skin of a frog, showing some large bundles of nerve-fibres ramifying upon its under surface. × 130.

Prep. 22.—Shows a small artery with bundles of nerve-fibres in the skin of the frog. The network formed by the different bundles is clearly seen. × 215.

Prep. 23.—Skin of the mouse, showing hair-bulbs, sebaceous glands, connective-tissue-corpuscles, and nerve-fibres. The coarse nervous network, and the fine network around the hair-bulbs are plainly demonstrated. × 215.

Prep. 24.—Shows nerve-fibres and capillaries, with their nuclei distributed to the peritoneum of the frog. The network formed by the different bundles of nerve-fibres is distinctly seen. × 130.

Prep. 25.—Another specimen from the peritoneum of the frog, showing a bundle of fine nerve-fibres, with one dark-bordered fibre, which divides. The dark-bordered fibre is observed continuing onward as a bundle of very fine fibres. Here are no separate pale fibres. Capillaries injected blue. × 215.

Prep. 26.—Shows the ultimate distribution of the nerves to the cornea of the frog. Not one dark-bordered fibre can be observed. The nerves, after dividing and subdividing, form a network of very fine fibres. The relation of the nerve-fibres to the cornea-corpuscles is clearly shown. The nerve-fibres always maintain their individuality at the periphery, and never lose themselves in the corneal-corpuscles or any other tissue. × 215.

Prep. 27.—Shows several bundles of very fine, pale fibres, distributed to the bladder of the frog. The bundles are seen repeatedly dividing, and at last forming a network which lies on different planes. Bundles of muscular fibre-cells are also observed interlacing with one another. Some of the nuclei of the muscular fibre-cells exhibit a triangular form, and the contractile tissue passes off in three directions. × 550.

Prep. 28.—Another specimen from the bladder of the frog, showing the termination of the dark-bordered nerve-fibres in very fine fibres, which form a network which ramifies in every part of the mucous membrane, and amongst the bundles of the muscular fibre-cells. × 700.

Prep. 29.—Ultimate distribution of the nerves to the muscles of the leg of *Hydrophilus piceus.* In the specimen some very fine bundles of nerve-fibres are observed crossing in different ways the muscular fibres, and passing from one fibre to others. The nerve-fibres of each bundle frequently join together, and form a very fine network over the sarcolemma. No connection can be demonstrated between the rows of nuclei in the contractile tissue and the nerve-fibres. The direction of the rows of nuclei is parallel to that of muscular fibres, while the nerve-fibres cross the muscular fibres either obliquely or transversely. It is beyond all doubt that the rows of nuclei delineated by Kühne, and stated by him to be connected with the terminal nerve-fibres, are nothing but the nuclei of the muscular fibre itself, which are imbedded in the contractile substance, and which take part in its formation. × 700.

Prep. 30.—Muscular fibres from the human heart. The nuclei, surrounded by granular matter, are seen in the centre of the fibres. The mode of growth of muscular fibre from the centre to the circumference is clearly demonstrated. Nerve-fibres and vessels, with their nuclei, may be also observed. We must recall to mind that in insects many muscles have central nuclei. × 130.

Prep. 31.—Shows the ultimate distribution of nerves to the cutaneous breast muscle of the frog. Several fine bundles of nerve-fibres are seen passing in different directions over the muscular fibres, and forming, after dividing and subdividing, a network with large meshes. Some of the muscular fibres, being in a state of contraction, prove conclusively that the nerve-fibres do not pass through the sarcolemma. Not one of the oval bodies described by Kühne as the peculiar organs in which every nerve-fibre ends beneath the sarcolemma can be seen. Only some nuclei are seen in connection with the nerve-fibre of the network. The termination of the nerve-fibres in free extremities, as has been stated by Kölliker, is also not observed. We must, however, say that some very fine nerve-fibres, after having been traced over the muscular fibres for a great distance, are at last lost sight of; but these may be followed for much greater distance from the dark-bordered fibre than the point at which Kölliker's fibres terminate. × 700.

On the Anatomy *of the* Nervous System *in the* Lumbricus terrestris. By James Rorie, M.D.

Up to a very recent date, anatomists have generally regarded the nervous system of the Insecta, Mollusca, and Annulosa, as consisting of a structure essentially different in its microscopical characters from that of man and the higher mammalia generally. The nerve centres of these animals, for instance, have usually been considered as composed of unipolar cells, from which minute fibres arise and pass directly to the muscles and organs supplied. That such an arrangement is the correct one has, however, now been called in question, not only on anatomical but also on physiological grounds; for if we admit that these nerve-cells are unipolar, then we must also admit that each cell is a separate nerve centre having no connection or relation with its neighbouring cells. This view, while opposed to all analogy, will be shown by the following notes to be equally opposed to correct observation. It is not, however, to be wondered at, that such a view should have been so generally received. On examining the nervous system, particularly of the Insecta, the appearance of unipolar cells is often presented, and it is only by very careful management of the light that a correct knowledge of the arrangement of the nerve-cells and nerve-fibres can be arrived at. In the present paper I propose to consider the anatomy of the nervous system of the common earth worm, (lumbricus terrestris,) because it presents to our view a nervous system of a very simple form, and especially because on account of its small size and transparency the different ganglia can be examined entire without our being obliged to have recourse to sections.

General anatomy.—In the *Lumbricus terrestris,* the nervous system may be considered as consisting of two parts, a supra-œsophageal portion and a ventral or infra-œsophageal portion.

The former or supra-œsophageal portion consists of two small spheroidal ganglia, situated immediately over the mouth of the animal, and connected together by a short commissure. From each of these ganglia a band of nerve-fibres pass downwards on either side of the œsophagus, and become attached to the first of the ventral or infra-œsophageal chain. The only nerve given off from this portion of the nervous system, is "a simple nervous filament," which, according to Brandt, "is continued from the œsophageal ganglion along the dorsal aspect of the alimentary canal," and which is by Owen considered to be the analogue of the great sympathetic and nervous vagus in the higher forms of animal life. We will, however, again refer to this question afterwards.

The infra-œsophageal or ventral portion of the nervous system consists of a number of ganglia so closely connected, that the appearance presented by this chain of ganglia is rather that of a flat knotted riband. The ganglia in this chain correspond in number with the number of rings of which the body of the animal is composed. They differ somewhat in size, becoming gradually smaller as we approach the caudal extremity. The first of this chain of ganglia is consequently the largest, and is triangular in shape. From each of the ventral ganglia, two nerves pass off, one from either side to supply the muscles, &c.

Microscopic anatomy.—On examining the nervous system of the lumbricus terrestis microscopically, with a carefully adjusted light and power of about 300 diameters, I found that the ganglia above described presented each a slightly different appearance and arrangement of the nerve-cells and nerve-fibres. It will suffice, however, to arrange them under three heads :—

1. Arrangement of the nerve-cells and nerve-fibres in the ventral ganglia generally.

2. Their arrangement in the first or sub-œsophageal ganglion ; and

3. The microscopical anatomy of the supra-œsophageal ganglia.

1. Arrangement of the nerve-cells and fibres in the ventral ganglia generally. On examining the fifth or sixth anglion of the ventral chains, I found it present the following appearance :—my description of which, the accompanying sketch (Pl. VIII, fig. 1), may assist in rendering more intelligible. The nerve-cells were all multipolar, those towards the sides of the ganglion being quadripolar, while those in the centre frequently gave off five, or even six branches. They were distinctly nucleated, very transparent, and possessing but little pigmentary deposit. The branches or nerve-fibres passing off from the lateral or quadripolar cells had the following arrangement: one passed inwards, and became continuous with one of the branches given off by the central multipolar cells; a second fibre passes upwards, and a third downwards or backwards, in the direction of the neighbouring ganglia; while the fourth is given off along the branch of distribution. In some of the ganglia a few fibres appeared to pass through the ganglion towards the branches of distribution, without having any connection with the nerve-

cells of that ganglion. This circumstance may account, in some measure, for the gradually tapering appearance of the whole chain.

2. Arrangement of the nerve-fibres and nerve-cells in the first or sub-œsophageal ganglion. This ganglion, as I have already stated, differs from the ventral ganglia generally in being of a triangular rather than of a quadrilateral form. It also differs in the nerve-cells not being so uniform in their arrangement. The quadripolar cells appear to be in a greater measure mixed up with those giving off more branches. As in the other ganglia, so here also some fibres may be seen passing through the ganglion without being connected with its nerve-cells. A sketch of some of the cells and fibres of this ganglion is given at fig. 2.

3. This microscopical anatomy of the supra-œsophageal ganglia (fig. 3). The minute anatomy of this portion of the nervous system differs to a considerable extent from that of the other ganglia. Each ganglion, or to speak more correctly, each hemisphere presents the appearance of being composed of two layers of nervous matter, differing from each other not only in colour, but also in microscopical character. The outer layer is of a reddish-grey colour, contains a considerable amount of pigmentary matters, and appears to be composed of spheroidal apolar cells, between which may be seen more or less granular matter. The inner layer, on the other hand, contains but little pigment, is transparent, and composed for the most part of multipolar cells. From these cells branches may be traced as follows:—From the outer cells fibres pass to form the ribbon-like collar surrounding the œsophagus, while, from the inner cells, fibres may be traced passing between the two hemispheres, thus forming a distinct commissure. Both classes of cells communicate freely with each other by means of other fibres; and, in addition, a few fibres are given off, which become lost in the granular matter of the outer layer. In fig. 3, a nerve is seen arising immediately from the cells of the transparent layer, and is, in all probability, the nerve referred to by Brandt.

With regard to the manner in which the nerves terminate at their periphery little is known. On the walls of the digestive organs of many Insecta they may be seen dividing and subdividing until they become lost to view, when examined with a power of 450 diameters.

Fig. 4 represents the appearance presented by one of the ganglia of the mussel (Mytilus), from which a few fibres may be seen, terminating in cells situated apparently in connection with a few fibres of the adductor muscle; but whether or not these last-mentioned cells have any definite relation to the muscular structure, I have as yet been unable to determine.

Having thus described the anatomy, general and microscopical, of the nervous system of the Lumbricus, a question very naturally arises—to what portion of the nervous system in man and the higher mammalia is the above type of nervous system analogous? The supra-œsophageal ganglia, both from their position and structure, are evidently the analogues of the cerebral hemispheres, but the ventral chain is not so easily disposed of. Some anatomists regard it as being analogous to the spinal cord, while others consider it as belonging to the sympathetic system. It would be foreign, however, to the present paper for me to enter at length into this question. I may here, however, state my opinion, and reserve my reasons for holding such an opinion for a future communication.

The supra-œsophageal ganglia I am inclined to regard as analogous to the cerebrum of man and the higher mammalia in a very rudimentary state, and with the spinal cord undeveloped. The ventral chain of ganglia I regard as belonging to the sympathetic system; the lateral quadrepolar cells being the analogues of the lateral ganglia in man; the central multipolar cells representing the central plexuses in the human subject. The flat, ribbon-like collar surrounding the œsophagus I believe to be the vagus nerve largely developed. Viewing the supra-œsophageal ganglia as an undeveloped cerebro-spinal system, and the ventral chain as a well-developed sympathetic system, and comparing these two portions of the nervous apparatus as we ascend in the scale of animal life, it will be found, as a rule, that as the cerebro-spinal system increases in size and development, the ventral or sympathetic system decreases in proportion.

EXPERIMENTS *on the* FORMATION *of* INFUSORIA *in* BOILED SOLUTIONS *of* ORGANIC MATTER, *enclosed in hermetically sealed vessels, and supplied with pure air.* By JEFFRIES WYMAN, M.D., Hersey Professor of Anatomy in Harvard College.

(From 'Silliman's Journal.')

PASTEUR in his admirable researches on fermentation has brought forward experimental evidence to show that this process depends upon the presence of minute organisms in the fermenting fluid, and that the source of all such organisms is the atmosphere. In support of this opinion he asserts, that when a fluid containing organic matter in solution is put into a flask and "boiled two or three minutes," and supplied only with air which has been filtered by passing through a tube heated to redness, and the flask is then hermetically sealed, no fermentation takes place, no organisms are formed, and that the contents remain indefinitely without change. But if the same solution is exposed to the air in its ordinary condition it becomes filled with various living forms. Out of a large number of experiments prepared in the manner above described, he has not known one to give a different result from that mentioned.* He further states that if the neck of the flask is drawn out into a very slender curved tube of several inches in length, the contents boiled, and then allowed to cool without the end of the tube being closed, so that the air enters at the ordinary temperature, and has free access to the interior of the flask, even then no fermentation takes place, and no organisms appear. His explanation of this is, that the air which enters first, meets with the hot steam, and the spores or organisms contained in it are killed, while those which enter the tube later move more slowly, and are deposited on the moist walls of it, without entering the body of the flask.†

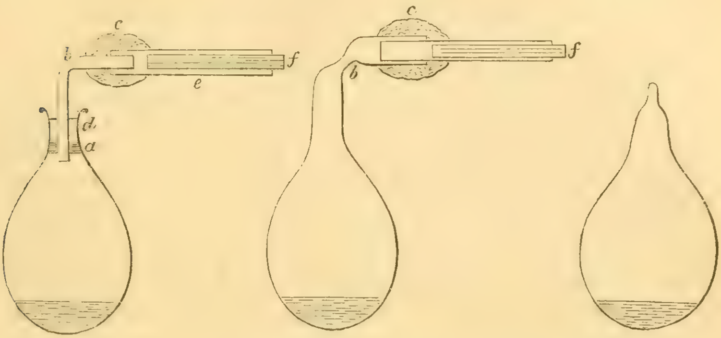
In most of the experiments given below, the results have been quite different, and living organisms have made their appearance in some instances where even greater precautions were taken than those mentioned by Pasteur. In order that the reader may understand what precautions were taken, we shall first describe the manner in which the experiments were performed.

(1.) In some instances (as in Experiments 1 to 5, 7 to 11, 13 to 15, 29 and 30 inclusive) they were prepared as in fig. 1. The materials of the infusion were put into a flask, and a cork *a*, through which was passed a glass tube, drawn to a neck at *b*, was pushed deeply into the mouth of it. The space

* "J'affirme avec la plus parfaite vérité que jamais il ne m'est arrivée d'avoir une seule expérience disposée comme je viens de le dire, qui m'ait donné un seul resultat douteux."—*Annales des Sciences Naturelles,* t. xvi, iv^me^ serie, 1861, p. 33.

† "Il semble que l'air ordinaire rentrant avec force dans les premiers moments doit arriver tout brut dans le ballon. Cela est vrais, mais il rencontre un liquide encore voisin de la temperature d'ebullition. La rentrée de l'air se fait en suite avec plus de lenteur et, lorsque le liquide est assez refroidé pour ne plus pouvoir enlever aux germes leur vitalité, la rentrée de l'air est assez ralenti pour qu'il abandonne dans les courbures humides du col toutes les poussieres capables d'agir sur les infusions, et d'y determiner des productions organisées."—*Ann. des Sc. Nat.*, 1861, t. xvi, p. 60.

above the cork was filled with an adhesive cement *d*, composed of resin, wax, and varnish. The glass tube was bent at a right



angle, and inserted into an iron tube *e*, and cemented there with plaster of paris *c*. The iron tube was filled with wires *f*, leaving only very narrow passage ways between them.*

(2.) Others (as in Exps. 6, 12, 16 to 24, and 21 to 23 inclusive), were prepared as in fig. 2, in which the joining at *a*, fig. 1, is avoided, and the iron tube is cemented directly into the mouth of the flask, the neck of which is drawn out at *b*, to render the sealing of it easy; otherwise, the conditions are the same as in fig. 1.

(3.) In other experiments (as in Exps. 24 to 28, and 24 to 28 inclusive), the flask, fig. 3, was sealed at the ordinary temperature of the room, and submerged during the period of the experiment in boiling water. This was the method followed by Needham and Spallanzani, and has the merit of eliminating all suspicions of error which might be supposed to arise from some imperfections in the joinings.

In the first and second methods, the solution in the flask is boiled, and at the same time the iron tube filled with wires is heated to redness. While the contents are boiling, the steam formed, expels the air from the flask; when the boiling has continued long enough, the heat is withdrawn from beneath the flask, and, as the steam condenses, the air again enters through the iron tube, the red heat of which is kept up, so that all organisms contained in the air are burned. In both methods the flask is allowed to cool very slowly in order that the entering air may be as long as possible in passing through the iron tubes, and thus the destruction of its organic matter

* An advantage in preparing the experiment in this way is, that the same flask may be used many times.

ensured. When cold, the flasks are sealed at *b*, figs. 1 and 2, with the blowpipe.

In experiments 29 and 30, a glass tube filled with asbestos and platinum sponge was used instead of the iron tube filled with wires.

The time during which the infusions were boiled varied, as will be seen by the records, from fifteen minutes to two hours, and the amount of infusion used from one twentieth to one thirtieth of the whole capacity of the flask, the object being to have the materials exposed to as large a quantity of air as possible.

In the account which follows, especial mention is made, in most instances, of the time of the formation of the "film." This is always the first indication which can be had, without opening the flasks, that minute organisms are developed; it is in fact made up entirely of them, as has been proved by repeated examinations with the microscope. It may first be detected in small patches, but soon covers the entire surface, and if the flask is gently moved so as to cause the infusion to change its position, the film adheres to the glass and is left by the liquid. In a few of the experiments no such film was formed.

After the flasks were prepared, they were suspended from the walls of a sitting room near the ceiling, where they were exposed to a temperature of between 70° and 80° Fahr. throughout the day and nearly the same during the night.

Experiment 1.* (1)† Feb. 3rd, 1862. A few grains each of sugar, gelatine and fine cut hay were introduced into a flask of 500 c.c. capacity, 20 c.c. of water were added, and the whole thoroughly boiled. A film formed on the surface of the fluid on the eighth day, the flask was opened on the ninth, and found to contain large numbers of Bacteriums.

Exp. 2. (1) Feb. 3rd. This was prepared in the same way as the preceding, excepting that pepper was added to the solution. The flask was opened on the twenty-ninth day and Bacteriums were found in great numbers.

Exp. 3. (1) Feb. 4th. A few grains of cheese, sugar and gelatine were dissolved in 17 c.c. of water, filtered and boiled in a flask of 500 c.c. capacity. A film formed on the nineteenth day, the flask was opened on the thirty-sixth, and found to contain Bacteriums.

Exp. 4. (1) Feb. 4th. Twelve cubic centimetres of a solu-

* In the first seven experiments the time which the contents were boiled is not stated, but it was in no instances less than fifteen minutes.

† The figures in brackets following the number of the experiment indicate which of the three modes of preparing the experiment was made use of.

tion like the preceding, with the addition of a small quantity of pepper was boiled in a flask of 250 c.c. capacity. It was opened on the twentieth day, but no living organisms were found.

Exp. 5. (1) Feb. 5th. A solution of sugar, gelatine, and cheese was boiled and filtered, and again boiled in the flask, which was opened on the twenty-ninth day, and no organisms detected.

Exp. 6. (2) Feb. 10th. A solution of gelatine and sugar to which was added a few drops of urine and milk, were put into a bolt-head, the tube of which had been drawn to a neck, and after boiling, was hermetically sealed. The flask was opened on the thirteenth day, and found to contain yeast plants and some very slender filaments which appeared to be of a vegetable nature.

Exp. 7. (1) Feb. 10th. Twenty cubic centimetres of a solution like the preceding was boiled in a flask of 875 c.c. capacity. A film formed on the eleventh day, and on the thirtieth the flask was opened, and found to contain Vibrios and Bacteriums.

Exp. 8. (1) Feb. 25th. A solution of sugar and gelatine to which fragments of green leaves and flesh were added, was boiled one hour and forty minutes. The flask was opened on the fifteenth day, no organisms were found.

Exp. 9. (1) Feb. 25th. The same as the preceding, without the addition of the flesh; this solution was boiled forty minutes and opened on the third day; no organisms were found.

Exp. 10. (1) March 6th. Three flasks, *a*, *b*, *c*, were prepared in the same way, each containing a solution of sugar and gelatine to which was added a few drops of urine and some fragments of muscle; *a* and *c* were boiled thirty minutes and *b* one hour. Air was supplied to *a* and *b* through a heated tube and to *c* at the temperature of the room. A film formed in *a* on the eleventh, and in *c* on the twelfth day, and at a later period in *b*. They were all opened a few days afterward, and found to contain Bacteriums, Vibrios and ferment cells.

Exp. 11. (1) March 12th. An ounce of meat was suspended in a flask of 850 c.c. capacity, with about 40 c.c. of water in it. This was boiled twenty minutes, during which time the meat was exposed to the steam in the flask. The juice which dropped from the meat was coagulated in the water beneath, and the meat itself was thoroughly cooked; on the second day the meat was covered with a gelatinous exudation, and on the third a film was formed on the surface of the water. The flask was opened on the fifth day, and found to contain Vibrios, Bacteriums, and a few ferment cells. The gelatinous exudation on the surface of the meat also contained the same organisms, and appeared to be wholly made up of them.

Exp. 12. (2) March 13th. The juice of an ounce of beef, to which was added 10 c.c. of urine and 40 c.c. of water was boiled twenty minutes in a bolt-head and hermetically sealed. A film formed on the fourth, and the flask was opened on the eleventh day, when there was a distinct rush of air outwards. Large numbers of Bacteriums were found, also small spherical bodies with ciliary motions and oval bodies like Kolpoda, containing what appeared to be Bacteriums; one of these Kolpoda-like bodies moved with cilia.

Exp. 13. (1) March 15th. An ounce of beef was suspended over water in a flask of 500 c.c. capacity and boiled twenty-five minutes. The same changes took place as in the preceding experiment. The exudation appeared on the surface of the meat, and the film on the water on the second day; on the fourth day the meat fell to pieces; the flask was opened on the ninth day; Bacteriums were found in large numbers, and there was a slight odour of putrefaction.

Exp. 14. (1) March 17th. Juice of beef and a few shreds of beef were boiled in a flask of 300 c.c. capacity for twenty seconds. A film was formed on the second day, and the flask was opened on the eleventh day. Bacteriums existed in abundance.

Exp. 15. (1) March 19th. Fifty cubic centimetres of beef were boiled forty minutes in a flask of 800 c.c. capacity. The film began to form on the second day, and the flask was opened on the 24th. The film had disappeared, the fluid had a nauseous odour, and the Bacteriums were diffused through the whole mass instead of being mostly confined to the surface as in the preceding experiments.

Expts. 16, 17, 18, 19. (2) March 20th. Were made with juice of beef and water in flasks of 550 c.c. capacity; 16 was boiled fifteen minutes, the film formed on the second day, and the flask was opened on the ninth. Vibrios were found in abundance, of different lengths, some of them moving with great rapidity. 17 was boiled thirty minutes, the film was formed on the third, and the flask was opened on the ninth day. Vibrios were found in great numbers, some of them bending and extending themselves rapidly. Some minute spherical bodies were also seen, having the kind of motion which results from vibrating cilia, though none of these were detected. Exp. 18 was boiled fifteen minutes, the fluid having been previously filtered; the film formed on the third, and the flask was opened on the eighth day; the organisms found were the same as in 17. Exp. 12 was boiled one hour, the film formed on the second, and the flask was opened on the twenty-fourth day. The infusion had a slightly putrid odour, and contained Vibrios and Bacteriums.

Exp. 20. (2) March 22nd. The flask and the contents of it were the same as in the experiments just described. The solution was boiled fifteen minutes, the film formed on the fifth, and the flask was opened on the thirty-first day. The fluid had become of a dark reddish-brown colour, the film had disappeared, and some of the shreds of the coagulated albumen had become nearly black. Bacteriums were found in large numbers, and the darker shreds seemed to be made up of them.

Exp. 21. (2) March 27th. Beef juice was boiled forty minutes, the flask was opened on the twenty-fifth day, and found to contain Bacteriums.

Exp. 22. (2) April 2nd. Beef-juice and fragments of beef were boiled fifteen minutes, and the air was introduced through a much smaller tube. Bacteriums were found on the twentieth day.

Exp. 23. (2) April 5th. Was prepared in the same way as the preceding experiment. The film formed on the sixth day, and the flask was opened on the seventeenth. The sealed end was melted in the flame of a spirit lamp, when the gas escaped with force. Bacteriums were found.

Expts. 24, 25, 26. (3) April 16th. Were all prepared in the same way. The capacity of the flasks was 550 c.c.; the contents were beef juice and water 17 c.c., urine 7 c.c. The flasks were folded in a napkin, immersed in water, which was gradually heated to the boiling point, and each then exposed to it for thirty minutes. The film formed in 26 on the fourth day, and in 24 and 25 on the fifth, and were all subsequently found to contain Bacteriums.

Expts. 27, 28. (3) April 24th. Two flasks, each of 550 c.c. capacity, and each containing about 20 c.c. of beef juice and urine, were hermetically sealed at the temperature of the room, wrapped in cloth, and exposed for two hours to boiling water. The film formed on the fourth day, one of them was opened on the fifth, and the other on the eleventh, and both found to contain Bacteriums.

Expts. 29, 30. (1) February 17th. In both of these the contents of the flasks were solutions of sugar and gelatine in water, to which fragments of cabbage leaves were added. The air was introduced through a Bohemian glass tube, filled with asbestos and platinum sponge, and heated to redness. The materials were boiled thirty minutes. In 29 the film was formed on the twenty-ninth, and the flask opened on the thirty-ninth day. The solution was found to contain Bacteriums and cells filled with them. In 30 the film was formed on the seventh day, and Bacteriums were found on the twenty-third, when there was a slight odour of putrefaction.

Expts. 31, 32, 33. (2) March 24th. Thirty grains of sugar, 20 c.c. of beef juice, 158 c.c. of water, were divided into three parts, and each part put into a flask of 550 c.c. capacity, and boiled fifteen minutes. No film was formed in either of them. 33 was opened on the thirtieth day; ferment cells and some filaments of a doubtful vegetable appearance were found. 32 was opened on the forty-second day, and found to contain ferment cells in large numbers, in different stages of cell multiplication; as in 32 there was an escape of gas.

Exp. 34. (3) March 27th. Juice of mutton, in a hermetically sealed flask, was boiled five minutes in a Papin's digester, under a pressure of two atmospheres. A film formed on the fourth day. It was opened several days later, in the presence of Prof. Gray, and found to contain Vibrios and Bacteriums, some of them moving with great rapidity.

Exp. 35. (3) The same as the preceding, and boiled in Papin's digester ten minutes, and under the pressure of five atmospheres. No film was formed. The flask was opened on the forty-first day. Monads and Vibrios were found, some of the latter moving across the field. No putrefaction; the solution had an alkaline taste.

Exp. 36. (3) March 28th. Beef juice was filtered and boiled, as in the preceding experiment, fifteen minutes, under two atmospheres. Opened on the forty-first day, and no evidence of life was found. When the end of the flask was heated, previously to opening, it collapsed.

Exp. 37. (3) March 28th. The same as the preceding; boiled fifteen minutes, under five atmospheres. Opened on the forty-first day, and no evidence of life was detected.

We have here a series of thirty-three experiments, prepared in different ways, in which solutions of organic matter, some of them previously filtered, having been boiled at the *ordinary pressure* of the atmosphere for a length of time, varying from fifteen minutes to two hours, and exposed to air purified by heat. In four instances, viz., in expts. 4, 5, 8, 9, the contents of the flasks were unchanged at the time they were opened; but in all of the rest, Bacteriums, Vibrios, or other organisms appeared. In nearly every instance their presence was indicated, in the early stage of the experiments, by the formation of a film, which took place in some on the second, and in others not until the nineteenth day, and was afterwards proved by a careful examination with the microscope. Prof. Asa Gray witnessed the openings of some of these flasks, and satisfied himself of the presence of Infusoria in the contents. Vibrios, Bacteriums, and Spirillums were the most frequently found, and in addition to these, as in expts. 10, 11, 12, 29, 31, 32, 33, either ferment cells, monads, or Kolpoda-like bodies were seen, some of them having ciliary movements. Those forms which were observed the most frequently are among the lowest, if not the lowest of all known organisms.

In many instances, a solution like that in the sealed flasks, and boiled for the same length of time, was exposed to the ordinary air of the room, in an open flask. Although the same forms were found in the two, they appeared much more rapidly in the open than in closed vessels, and the contents of the former soon became putrid, while those of the others, at the time of opening, were mostly not, and in a few instances only slightly so.

We have, in addition, four experiments, viz., 34, 35, 36, 37, made under *increased pressure,* and sealed by the third method; 34 and 36 were boiled five and ten minutes respectively, under two atmospheres, and 35 and 37, under five atmospheres for ten and fifteen minutes respectively. Evidence of life, consisting of Monada and Vibrios, was found in 34 and 35, but none in the others.

The result of the experiments here described is, that *the boiled solutions of organic matter made use of, exposed only to air which has passed through tubes heated to redness, or enclosed with air in hermetically sealed vessels, and exposed to boiling water, became the seat of infusorial life.*

The experiments which have been described, throw but little light on the immediate source from which the organisms in question have been derived. Those who reject the doctrine of spontaneous generation in any of the forms in which it has been brought forward, will ascribe them to spores contained either in the air enclosed in the flask, or in the materials of the solution. In support of this view it may be asserted, that it has been proved by the microscopical investigations of De Quatrefages, Robin, Pouchet, Pasteur and others, that the air contains various kinds of organic matter, consisting of minute fragments of dead animals and plants, also the spores of cryptogamous plants; and certain other forms, the appearance of which, as De Quatrefages says, suggests that they are eggs.* We have made some examinations of our own on this subject, but it would be unnecessary to give the results in detail. We will simply state, that we have carefully examined the dust deposited in attics, also that floating in the air collected on plates of glass, covered with glycerine, and have found in such dust, in addition to the *débris* of animal and vegetable tissues, which last were by far in the greatest abundance, the spores of Cryptogams, some closely resembling those of Confervoid plants, and with them, but much less frequently, what appeared to be the eggs of some of the invertebrate animals, though we were unable to identify them with those of any particular species. We have also found grains of starch in both kinds of dust examined, to the presence of which Pouchet was the first to call attention. When compared with the whole quantity of dust examined, or even with the whole quantity of organic matter, both eggs and spores may be said to be of rare occurrence. We have not in any instance detected dried animalcules which were resuscitated by moisture, and when the dust has been macerated in water, none have appeared until several days afterwards, or until after a lapse of time, when they would ordinarily appear in any organic solution.

Those who advocate the theory of spontaneous generation, on the other hand, will doubtless find, in the experiments here recorded, evidence in support of their views. While they admit that spores and minute eggs are disseminated through the air, they assert that no spores or eggs of any kind have been actually proved by experiment to resist the prolonged action of boiling water. As regards Vibrios, Bacteriums, Spirillums, &c., it has not yet been shown that they have spores; their existence is simply inferred from analogy. It is certain that Vibrios are killed by being immersed in water, the temperature of which does not exceed 200° Fahr. We have found all motion, except the Brownian, to cease even at 180° Fahr. We have also proved by several experiments that the spores of common mould are killed, both by being exposed to steam and by passing through the heated tube used in the experiments described in this article. If, on the one hand, it is urged that all organisms, in so far as the early history of them is known, are derived from ova, and therefore that from analogy, we must ascribe a similar origin to these minute beings whose early history we do not know,

* See an abstract of Pasteur's "Researches on Spontaneous Generation," 'Am. Jour. Science and Art,' vol. xxxii, 1, 1861.

it may be urged with equal force, on the other hand, that all ova and spores, in so far as we know anything about them, are destroyed by prolonged boiling; therefore, from analogy we are equally bound to infer that Vibrios, Bacteriums, &c., could not have been derived from ova, since these would all have been destroyed by the conditions to which they have been subjected. The argument from analogy is as strong in the one case as in the other.

CAMBRIDGE, U.S.; *May 9th*, 1862.

TRANSLATIONS.

On the STRUCTURE *of the* VALVE *in the* DIATOMACEÆ, *as compared with certain Siliceous Pellicles produced artificially by the decomposition in moist air of Fluo-silicic Acid Gas (Fluoride of Silicium.)* By Prof. MAX SCHULTZE.*

THE following pages contain only an abstract of Professor Schultze's observations, which are too long to be given entire. The subject appears to be one of considerable interest, notwithstanding that, so far as the nature of the marking on the Diatomaceæ is concerned, opinions may not, at the present day, be so much divided in this country as the author appears to think.

On the addition of sulphuric acid to a mixture of powdered fluor spar and sand, an immediate evolution of fluoride of silicium takes place, as is evidenced by the white fumes. This whiteness, as is well known, is produced by the presence of minute particles of silex arising from the decomposition of the fluoride on its coming in contact with the aqueous vapour contained in the atmosphere. If a solid body be exposed to these vapours, a portion of the silex will be deposited upon it in the form of a fine, white powder, the quantity of which is greater in proportion to the amount of aqueous vapour present in the air. If the experiment is performed in a wide-mouthed flask, in the neck of which a short tube of moistened filtering paper has been placed, the siliceous deposit is so abundant on the inner surface of the tube that its calibre is soon, either entirely or partially, filled with a snow-like mass. But even without the moist paper tube, a gradual deposit is formed at the mouth of the flask, which, in the course of a day or two, will usually be found occupied by a plug of finely divided silex.

The peculiar microscopic character of the siliceous deposit

* 'Verhandl. d. Naturhist. Vereins der preussisch. Rheinland u. Westphal.,' Jahr. xx, p. 1.

thus produced was first pointed out to the author by Professor Heintz, of Halle, some years ago. The silex is deposited in the form of thin-walled vesicles, of various dimensions and forms, as spherical, pyriform, or subcylindrical, and usually filled with air, so that they float on the surface of water. If some of the deposit be crushed between two pieces of glass, and examined with a power of about 300 diameters, a marking will be perceived on the outer or convex surface of many of the fragments of these vesicles similar to that of many Diatomaceæ, such as *Pleurosigma, Coscinodiscus,* &c. Rounded elevations, more or less hexagonal at the base, and more or less regularly arranged, cover the surface of the siliceous pellicle, and not unfrequently this kind of marking is so regular as to give the fragments exactly the appearance of portions of diatomaceous valves.

This remarkable circumstance struck the author very strongly, but the investigation of the subject was not pursued until his attention was again awakened to it by the appearance of a paper by H. Rose, "On the Different Conditions of Silicic Acid," in Poggendorff's 'Annalen' for 1860, p. 147, in which that chemist pointed out more fully than had previously been done the difference between amorphous and crystallized silex, with respect to their physical and chemical properties.

In this paper especial stress was laid upon the difference in the specific gravity of the two forms as a diagnostic character between them, although the existence of such a difference had been, to some extent, previously known.

In crystalline silex the sp. gr. is pretty constantly 2·6, whilst in the amorphous form it never exceeds 2·3, and is usually much under that, and even may not exceed 1·8.

Under the circumstances, therefore, it became a matter of considerable interest to determine the specific gravity of the silex deposited in the way above mentioned. The results of three experiments made by the author at different times, to determine this point, gave as the sp. gr. of this form of silex —2·437, 2·61, 2·58, or a mean of 2·54.

The appearances presented under the microscope by the siliceous pellicles were such as to suggest that they were due possibly to crystallization. The minute elevations on the surface, when viewed on the side, often appear sharply acuminate, so as readily to convey the impression that they are formed by minute crystals of silex; and this impression is strengthened at first sight by their sharply defined, hexagonal bases, when viewed vertically. The circumstance, again, that these elevations are sometimes rounded at the summit and circular at the base, might be attributed to the accidental interference of free hydrofluo-silicic acid, &c. But experiments to eliminate the action of this agent showed that it had nothing to do with the variety of appearance in the elevations.

The subject presented no less interest as regards the explanation of the peculiar structure of the diatomaceous valve. Most of the manifold species of these organisms are characterised by the presence on their outer surface of certain differences of relief, referable either to elevations or to depressions disposed in rows. The opinions of microscopists with respect to the nature of this marking are divided. Whilst in the larger forms and those distinguished by their coarser dots the appearance is manifestly due to the existence of *thinner spots* in the valve, we cannot so easily explain the cause of the so-termed striation or punctation in *Pleurosigma angulatum,* and similar delicately marked forms. In these it often seems as if the appearance were due to pyramidal elevations, with hexagonal bases, and standing in regular rows, exactly like those observed in the siliceous vesicles above mentioned.

In any case, it seemed likely, since the marking just noticed is observed to be essentially alike in many different species of diatoms, that its ultimate cause were to be sought, less, perhaps, in any organic formative process, than in the deposition of silex under the same laws as those by which its deposition in the other case is regulated. Were this ultimate cause shown to be *crystallization,* the question would be solved.

But in other cases, that the secretion of amorphous silex also occurs in the diatoms is undeniable. The specific gravity of the diatoms in the so-termed infusorial earth of Lüneburger-Haide has been determined by Graf. Shaafgotsch to be 2·2, showing clearly that in this case the silex is in the amorphous condition. But the diatoms in this deposit do not belong to those characterised by the surface marking, which, as has been hinted, might be referred to crystallization. They are *fresh-water forms,* whilst that kind of marking is more especially peculiar to the *marine* diatoms in general. It may be supposed that the sea-water is favorable to the deposition of silex in the crystalline condition. The author was induced, in consequence, to take considerable pains to determine the sp. gr. of the marine diatoms, collected together in considerable quantity, but in vain, owing to the circumstance that they are so abundantly mixed up with other siliceous bodies of clearly amorphous nature, such as sponge-spicules, Polycystina, &c., as to render their separation impossible.

But how is it that, according to Ehrenberg and others, the diatom-valves do not possess double refraction, like crystallized silex? In reply to this, it may be said that Hugo von Mohl has lately asserted,* in opposition to previous statements, that, with the very essential improvement in the polarizing apparatus introduced by him, *P. angulatum*, with its hexagonal spots, appears so distinctly doubly refractive, that even the hexagons on the surface may be perceived with the Nicol's prism, and consequently upon a dark field.

It may be added that the artificial siliceous pellicles are very distinctly doubly refractive. Thus, on this account, there is nothing opposed to the explanation of the structure of certain diatomaceous valves, as being due to crystallization of the silex. And this supposition is materially supported by the results of the experiments above related, with respect to the specific gravity of the pellicles. These results are, at any rate, compatible with the notion of a mixture of crystallized and amorphous silex in those bodies.

But further investigation rendered the correctness of this assumption in the highest degree doubtful, and it soon became quite certain that *neither in the artificial siliceous pellicles nor in the diatom valves* are the peculiar forms due to a crystalline structure.

In the first place, it clearly appeared that the pellicles in question are not, as it was at first supposed, pure silex. It was manifest further that—(1). These pellicles contain a constant quantity of fluorin or of fluoride of silicium. When the latter was expelled by a red heat, the substance was found at once to possess the low sp. gr. of amorphous silex. (2). The phenomena of double refraction afforded by them are not the same as those exhibited by *rock crystal;* that is to say, not like those presented in a body with a *positive axis* of double refraction, but resembling what is seen in substances with *negative* double refraction. (3). The appearances described by H. von Mohl, and confirmed by Valentin, as being due to double refraction, exhibited in certain diatoms, are not phenomena due to double refraction at all, but are to be referred to *depolarization by refraction.* They are no longer visible when the valves are immersed in Canada balsam or other medium possessing a similar refractive power to silex.

The author then proceeds to detail the methods by which

* Poggendorff's 'Annalen,' 1859, Bd. cviii, pp. 179—185; 'Botanische Zeitung,' 1858, p. 10.

the chemical composition of the pellicles was determined by Professor Landolt, for which we must refer to the original, and goes on to discuss their doubly refractive property above referred to. The existence of this property in them is readily shown by means of the common polarizing apparatus, although for the closer study of the phenomena it is necessary to employ H. von Mohl's *illuminating lens* in connection with the lower Nicol's prism.

Owing to the great differences presented by these pellicles as regards thickness, it is obvious that the phenomena of double refraction will vary very much in distinctness. In the thinnest, most delicate, and immeasurably fine pellicles, they can scarcely be perceived at all; whilst, on the other hand, it increases in distinctness in proportion to the thickness. The vesicles best fitted for examination in this regard are those of a nearly spherical form, with thick walls, on whose surface minute elevations are seen arranged in regular rows, as shown in fig. 1 (Pl. VIII, B). A hollow sphere of this kind appears under a Nicol's prism, as an illuminated ring on a black ground; the width of the ring differing according to the thickness of the wall. The ring is subdivided into four quadrants by a black cross. It exhibits no colours. As regards the elevations on the surface, it is obvious that those situated in the centre of the sphere, and consequently whose points are presented to the observer, exhibit no indication of double refraction, whilst those at the periphery of the sphere, nearer the light, possess the power of double refraction the more distinctly the more nearly the direction of their axis approaches the horizontal.

The author then proceeds at considerable length to compare the phenomena of double refraction exhibited in the artificial siliceous vesicles with what is observed in other siliceous bodies or minerals, such as opal, hyalite, different varieties of siliceous sinter, silicified woods, &c. The general result at which he arrives is that, as regards structure and optical property, there are two kinds of amorphous siliceous minerals—1, those which are perfectly homogeneous, and which exhibit *no indication whatever of double refraction*, of which the precious opal is a good example; and, 2, those whose structure presents a *fine, concentric lamination*, and which form spherical or botryoidal masses. These exhibit double refraction, which property is connected with the laminated structure, and is always *negative*. To this class belong hyalite, siliceous sinter, and other allied minerals.

The production of these phenomena, as the consequence of the unequal tension of the different layers, is then very clearly explained by reference to experiments with unequally heated or cooled glass-globules, starch, &c. The subject is also well illustrated by an experiment with minute homogeneous glass-globules, coated with successive layers of collodion, and which, when immersed in Canada balsam, exhibit very distinctly, under a Nicol's prism, the property of negative double refraction.

Returning now to the further consideration of the structural and sculptural conditions exhibited in the artificial siliceous pellicles, and to the comparison of the latter with the apparently similar markings on the diatomaceous scales, Professor Schultze goes on to remark that the surface of the bodies in question, when their formation has taken place gradually and uninterruptedly, almost always presents minute, more or less sharply acuminate elevations, disposed in regular or irregular order.

The smaller they are the more regular usually is their arrangement, instances of which will be seen in figs. 7, 8, 9, which represent the appearance seen in these pellicles under a magnifying power of 350 diameters. Viewed in front, these preparations closely resemble the valve of *Pleurosigma angulatum*, as it appears under a power of 800 diameters with one of Amici's or Hartnack's immersion-lenses. The most marked difference is in fig. 9, which represents a side view, at the borders of which the elevations are distinctly visible, an appearance which does not exist in the diatom in question. But a still finer punctation, visible only under the highest powers, may be observed in the thinner artificial pellicles, so that a series of test-objects for any lenses hitherto constructed might be chosen from among them.

This finer kind of relief-sculpture, however, affords but little insight into its nature. The only impression conveyed by it is that the entire pellicle, or, at any rate, its outer surface, is constituted of minute, closely contiguous spherules, some of which are acuminate.

Far more instructive are the larger hemispherical or conical elevations, which may frequently be seen, disposed with great regularity, as in figs. 3, 5; sometimes intermixed with smaller ones, either regularly or irregularly (fig. 10). These elevations are either regularly or irregularly hexagonal at the base, or even circular, as in fig. 10. If the specimens be immersed in water, with the summits of the elevations pointing upwards, these appear as bright points in a dark field when the microscope is focussed accurately upon them, the appearances presented varying, however, it is almost needless to say, according to the focal distance at which the object is viewed, though all are reconcilable with the existence of conical, acuminate elevations, such as are represented in the side view in fig. 9. Another set of appearances may be illustrated by figs. 6 and 6 *a*, the latter being the profile view. These are found when the elevations, instead of being pointed or acuminate, are rounded and obtuse at the summit. The elevations in this case, when viewed at the proper focal distance, are distinguished by their presenting one or more concentric rings. The appearances presented in both cases—that is to say, in the pointed or acuminate elevations, and in the rounded or obtuse ones—are all explicable upon the assumption of their being composed of superimposed laminæ, gradually diminishing in size.

It is to be observed that, however constant is the occurrence of these elevations on the *outer* surface of the vesicles, the *inner* surface, more especially in the thicker-walled ones, is always smooth and even.

What has been said above with respect to the structure of the siliceous vesicles suffices to afford a notion as to the mode in which their gradual formation occurs; and repeated observations leave no doubt that this takes place in the following way:—The first deposition of silex is in the form of minute spherules or lenticular particles, which usually aggregate themselves into pellicles, constituting, for the most part, spherical or cylindrical vesicles, *which, however, never, or at any rate very rarely, appear to be entirely closed.* The size of these siliceous particles varies extremely, for reasons which are not, in all cases, easily determined, but which have manifestly some relation to the rapidity with which the evolution of the fluoride of silicium takes place. Fig. 4 represents a transverse section of a portion of a vesicle composed of the larger kind of lenticular particles. These particles at first project equally on both surfaces; but this condition is soon altered, owing to the circumstance that the continued deposition of silex does not go on uninterruptedly over the whole outer surface, but only or chiefly on the elevations, which, consequently, assume the form of convex lenses, which, as they increase in size and interfere with each other, gradually acquire hexagonal outlines. The pellicle, however, increases in thickness internally as well, but on this aspect the deposition goes on uniformly over the surface, the consequence of which is that the hollows are gradually filled up and the elevations obliterated (fig. 3). It seems probable that this internal thickening may go so far as wholly to obliterate the cavity; and thus a solid spherule of silex is formed, presenting, as above stated, the optical properties of hyalite;

though some of these solid spherules may also arise from deposition on the outer surface of originally very minute spherules.

Passing over the extremely various and often very delicate structures detected by microscopic examination among these siliceous bodies—all of which, moreover, are referable, in one way or another, to the fundamental type above described—the author proceeds to discuss the question of the *structural relation between these artificial pellicles and the valves of diatoms*, many of which exhibit in their markings so close a resemblance.

The similarity between the finely marked diatom-valves *which exhibit three sets of lines*—as, for instance, in *Pleurosigma angulatum*, &c.—with some of the similarly finely marked artificial pellicles (as shown in figs. 7 and 8) is so great, that at first sight the sculpturing would seem to be identically the same. In the one case, as in the other, a central or direct illumination brings into view minute points, disposed in regular rows, whilst oblique illumination produces three sets of lines, cutting each other at an angle of 60° or 120°. In the one case, also, as in the other, with central illumination the appearance alters according to the focal distance at which the object is viewed; sometimes regular hexagons being brought into view, whilst at another merely minute serial dots are visible. But the marking, he states, in *Pleurosigma angulatum* and allied forms comes so close to the boundary of the recognisable, that a clear perception of the systems of lines or elevations by means of *central* illumination, and without the aid of artificial illumination—as by a condenser, &c.—is possible but with few microscopes. So far as he is aware, this object can be effected only with the most powerful combinations constructed by Amici, Nachet, and Hartnack, Nos. 9 and 10, *à immersion*, or more recently by the latter's No. 9 without immersion. In fact, under such circumstances, an investigation with respect to the true fundamental cause of so obscure a marking may be termed bold. Is it due to pyramidal elevations on the surface, as on the thicker pellicles (fig. 5), or to depressions or conical hollows; or is the appearance due to some totally different structure in the substance itself of the valve, and having nothing to do with differences of relief on the surface?

The answer to these questions has been often sought, but it has by no means been unanimous. The only thing that is quite positive is that the marking in question is due to actual *differences of relief* on the outer surface of the valve.

Wenham* was struck with the happy thought of preparing galvano-plastic impressions of diatoms, which were in his hands perfectly successful, and represented *impressions of the systems* of lines or dots. For this purpose he selected only two species, *Pleurosigma balticum* and *P. hippocampus,* both of which are among the very finely marked diatoms, though far more easy resolvable than *Pleurosigma angulatum.* They differ from the latter also in the circumstance that, when we view the systems of lines more particularly as brought out by oblique light, in the former two species only two sets will be perceived, crossing each other at a right angle, whilst in *P. angulatum* three will be seen intersecting each other at an angle of 60°. An explanation, therefore, of what is seen in the former need not be equally true of the latter. But the general aspect of both species, except in the above respect, is so much alike that no one could object to the application of Wenham's explanation of what is seen in *P. balticum* to the appearance presented in *P. angulatum.* It is true that Schacht† has lately given a description of the marking which might raise a doubt whether the three sets of lines in question are really situated on the surface of the object. He says—"In order to display each set of lines, it is in many cases necessary, besides the turning of the stage, to alter the focus somewhat, from the circumstance that each of the three sets of lines *belongs to a distinct layer in the valve,* and consequently is placed a little above or beneath the other." And this he says notwithstanding that, as he himself allows, all the three sets may be brought into view *at once.* Further on it is said—"The horizontal lines appear to be the deepest seated, and are, perhaps, on that account the most faintly marked." The apparently moniliform structure of these diatom-valves, consequently, according to Schacht, is deceptive, and is only perceived in case the successive sets of lines, when, as under certain circumstances, they come into view simultaneously, are viewed altogether. Upon what conditions, therefore, he considers the striation really to depend remains obscure, although in a subsequent passage Schacht, in explaining the matter, employs the ex-

* 'Quart. Journ. Mic. Sc.,' III, 1855, p. 244. It does not appear that Mr. Wenham's experiments were limited to the two species named, as he says that he had "obtained distinct impressions of the markings of some of the more difficult Diatomaceæ, such as *N. balticum*, *P. hippocampus*, &c., leaving," he goes on to say, "no doubt of their prominent nature." But whether this prominence belongs to the areolæ or intermediate lines does not appear.—Eds.

† 'Der Mikroskop und seine Anwendung,' 1862, p. 29.

pression of "raised ridges," three sets of which, according to him, of equal breadth and decussating with each other at an angle of 60°, exist in *P. angulatum.* From this it would seem that he had given up the notion that the sets of lines were situated at different levels, as "*raised* ridges" can hardly be imagined to exist except on the surface.

When any one of the three species of *Pleurosigma* above named is examined under a high magnifying power and with a central illumination, rows of points will be seen on its surface, varying in brilliancy according as the body of the instrument is raised or lowered. In *P. hippocampus* and *balticum* these points are placed in two series at right angles to each other, whilst in *P. angulatum* they form three series, decussating, as above said, at an angle of 60°. They may be viewed either as bright spots upon a dark ground or as dark ones upon a bright ground,* and it has been disputed which appearance indicates the "proper focal distance."

Welcker's† excellent, though strangely neglected observations, have shown the futility of such a dispute. By them we are at once enabled, in the most precise way, to answer the next interesting question, viz., as to whether the points on the surface are the expression of *elevations* or of *depressions*. The readers of the 'Microscopical Journal' are aware that, with respect to this point, much contention has been carried on in England, and that the opinions of microscopists with respect to it have been directly opposite. Whilst Carpenter, confessedly one of the greatest English authorities on any questions of microscopy, and, with him, many other observers, holds these points to be *depressions,* relying, in support of this view, as does Harting, particularly upon the analogy with the more coarsely marked diatoms, in which the marking on the surface certainly depends upon series of depressions, the opposite view has, nevertheless, continued to gain ground, and to be advocated by no less skilful observers. Amongst the more eminent of these is Dr. Wallich,‡ who, by the use of oblique light—which he prefers in all cases—believes that he has ascertained beyond question, that the marking on *P. angulatum, balticum,* &c., is produced by *pyramidal* sharp facets, and finely acuminate elevations on the surface.

* Hall, 'Quart. J. Mic. Sc.,' IV, Pl. XIII, fig. 2.

† Ibid., VII, p. 240, and VIII, p. 52.

‡ 'Ann Nat. Hist.,' Feb., 1860. *Vide* also 'Q. J. Mic. Sc.,' VI, 1858, p. 247, where it will be seen that in some caes, as, for instance, in *Triceratium favus*, Dr. Wallich recognises the existence of distinct hexagonal cells on the surface. Though he is inclined (ib. viii, p. 142) to deny that any analogy exists between the marking on that genus and that of *Pleurosigma*, &c.

Amongst other observers who are inclined to adopt this view may be cited Mr. G. Norman, of Hull, than whom few possess a more intimate knowledge of diatoms.* It is curious, in this state of the question, that the method of observation proposed by Welcker, though not for this special purpose, should not have been employed. Welcker states, as a means of distinguishing, in all transparent objects, superficial elevations from depressions, that *elevations* appear brightest when the body of the microscope is raised, whilst *depressions*, on the contrary, are brightest when it is depressed. If we start, then, with the body of the microscope at a medium height, or lowering it gradually upon the object from a height altogether out of focus, in this case elevations on the surface will first appear as bright points on a dark ground, and depressions as dark points on a bright ground, until, as we continue to lower the tube, the image in either case is reversed. It is only requisite to observe that the object should be mounted in a medium having a lower index of refraction than itself.

The reason of this is, as stated by Welcker, because the elevations act as convex and the depressions as concave lenses, the bright points representing the focus of each respectively, and consequently corresponding in the one case to the summit of the *elevation* and in the other to the bottom of the *depression*.

In proceeding to apply this rule to diatoms, it will be most convenient to select dry preparations, in which the first condition, viz., that objects should be placed in a less refractive medium, is fulfilled, and in which also, as is well known, the superficial markings are most readily made out. But even with a magnifying power of 1000 diameters and more, and with excellent lenses, capable of distinctly bringing out the markings on *P. angulatum* with direct illumination, we shall soon be convinced that the subject, even as regards the more easy images of *P. balticum*, *attenuatum*, and *hippocampus*, still presents unforeseen and almost insuperable difficulties.

An indispensable precaution to be taken to ensure success in this inquiry is that an individual point in the marking should be so distinctly fixed upon that it may be recognised under various alterations of the focus. But the points and series of points of the diatoms above named are so closely approximated that this object demands considerable effort and skill. The author thinks he has been successful in the attempt in the case of *P. balticum*, and has satisfied himself

* 'Quart. Journ. Mic. Sc.,' July, 1862, p. 212.

that although, upon gradually focussing down upon the surface, *clear* points, though not altogether precisely defined, come *first* into view, and *then dark* ones, the two sets of points do not correspond with each other, but that the dark points make their appearance *between* the bright ones which first came into view. When the clear points are ill defined, the dark ones, on the other hand, are very distinctly shown, quadrangular in *P. balticum* and hexagonal in *P. angulatum*. These dark points, again, when the tube is still further lowered, in their turn become bright, a second time to become dark when the tube is still further depressed. Lastly, the lowering of the tube being continued, we again have a sort of confused or blended image of bright points. Thus, for instance, in *P. angulatum*, in which the succession of *dark, bright, dark,* is very manifest, an indistinct appearance of bright points precedes all.

The explanation of these alternating images is not easy, according to Welcker's idea, though everything seems to the author to signify that it takes place in the following manner: —The *dark* points brought into view upon the accurate focusing arrived at by the *lowering* of the tube manifestly represent *depressions.* The indistinct *bright* points by which they are preceded do not coincide exactly with them in position, but may rather be said to be contiguous to them, and to represent, consequently, the *borders* of the depressions. The dark points which, more particularly in *P. angulatum,* are seen arranged with beautiful regularity over the whole surface of the valve, present, on the further lowering of the tube, a *bright* appearance, whilst at the same time their borders become darker. At this point the bottom of the depression may be said to have been reached. So far all is clear. The borders of the pits form the system of ridges, which by oblique illumination appear as the lines. The intermediate pits, either quadrangular or hexagonal, according to the number of the ridges, are seen as dark points so long as their bottom is not distinctly in focus. But the borders also of the depressions, when the tube is raised, may appear like illuminated *points,* because at the spots where two or three ridges decussate, or where one of them is abruptly bent, the reflection of the light gives the deceptive appearance of a projecting eminence or point. This latter appearance, however, as has been stated, is of an indistinct kind. It follows, therefore, that neither spherical, conical, nor pyramidal elevations are the cause of the punctated appearance on the surface of the above-named species of *Pleurosigma,* although the decussating sets of ridges may at the points of intersection, afford an appearance resembling that of tubercular elevations.

But how is the circumstance to be explained that, upon the still further lowering of the tube, the appearance of the bright points corresponding to the bottoms of the depressions is again succeeded by that of dark ones? With respect to this, the author is only able to surmise that on the *inner* surface of the valve there is a sculpturing similar to that on the *outer;* and, consequently, that when, by the lowering of the tube, the borders of the inner depressions are brought accurately into focus, the depressions themselves appear as dark points. And in the same way may be explained the ultimate indistinctness of the previously bright, punctiform markings.

In cases where two sets of lines intersect each other at a right angle, as in *P. balticum, hippocampus,* and *attenuatum,* the disposition of the ridges at once suffices to account for the arrangement of the quadrangular interspaces. But it is not so easy to explain the disposition of the hexagons produced by the three sets of ridges intersecting each other at an angle of 60° which exist in *P. angulatum* and its allies. It is most natural to suppose that they would be arranged like the cells in a honeycomb, that is to say, in the manner shown in fig. 11. An arrangement of this kind is figured amongst others by Carpenter and Mr. Ch. Hall.* Schacht, however, gives a different view of the arrangement of the hexagons. According to him, they are not in accurate mutual contact, like the cells in the honeycomb, but so disposed as to leave between them minute triangular spaces. These interspaces, then, might either, like the hexagons themselves, represent depressions, or might be elevations, and in this case conduce to the formation of the borders of the depressions. The author has never been able to see these triangular interspaces, and cannot coincide in Schacht's opinion as to the boundaries between the hexagons being formed by sets of continuous elevated ridges. That the hexagons are arranged as figured by Mr. Hall, that is to say, like fig. 11, is fully established to the author's satisfaction by some photographic representations procured by the aid of Hartnack's combination. According to these figures, the lines in each set are not continuous in a straight direction, but are bent at short intervals, at an angle of 120°. These bends are, however, so close together as to be imperceptible with the power usually employed in the examination of *P. angulatum,*

* 'Quart. Journ. Mic. Sc.,' Vol. IV, 1856, Pl. XIII, fig. 2. *Vide* also 'Micrographic Dictionary,' 1856, pl. xlvii, figs. 41 and 48, the former of which is copied from a photograph by Mr. Wenham.

that is, with one of from 500 to 800 diameters. It is especially by oblique light, under which only it is generally the case that the sets of ridges appear as continuous striæ, that the illusion becomes perfect that we are beholding sets of lines running in a perfectly direct course; whilst observation with direct illumination, provided that the lenses have sufficient defining power, discloses the true state of things. By such a light, with Hartnack's immersion-lens No. 10, Fig. 11, representing a portion of the surface of the valve of *P. angulatum*, was drawn.

The author then proceeds briefly to discuss the nature of the appearances presented in the more coarsely marked diatoms, such as *Coscinodiscus, Eupodiscus, Biddulphia,* and *Isthmia,* and shows that these appearances may be explained in the same way as those of *Pleurosigma.* In *Isthmia,* more particularly, he says, it may be readily shown that the quadrangular areolæ are not elevations on the surface, but rather holes in the valve, which consequently is formed of a kind of lattice-work, like that of many of the Polycystina. In *Coscinodicus* and *Eupodiscus* the existence of a similar network is not so easily made out, that is to say, it is difficult to determine whether the areolæ represent actual openings in the valve, or, as is more probable, are not merely very thin spots. In specimens of these diatoms mounted in Canada balsam the appearances, explained according to Welcker's plan, are not reconcilable with the view of the areolæ being depressions, but the reverse. This the author explains by stating that the Welckerian phenomenon is reversed in objects immersed in a medium of greater refractive power than themselves. In specimens immersed in water, or dry, the true appearances are at once displayed.

It is thus shown that the sculpturing, *both in the coarsely and in the finely marked* diatom-valves, although at first sight apparently allied to what is seen on the surface of the siliceous pellicles, is in reality due to wholly different conditions.*

* It may be as well here to recall to microscopical observers that, on the occasion of the reading of Dr. Wallich's paper on the diatom valve ('Q. J. Mic. Sc.,' VIII, p. 129), Mr. Wenham, whose opinion on any matter of the kind is of the greatest weight, stated that with an object-glass of his own construction, with a focal distance of $\frac{1}{50}$th inch and a large aperture, he had ascertained beyond doubt that in *P. angulatum* and some others the valves are composed wholly of spherical particles of silex, possessing high refractive properties. And he showed how all the various optical appearances in the valves of the Diatomaceæ might be reconciled with the supposition that their structure was universally the same. It would be interesting to know whether Mr. Wenham retains this opinion.—EDS.

The paper concludes with some observations upon the phenomena afforded by diatom-valves under polarized light. H. v. Mohl has stated* that he observed, by means of his improved polarizing apparatus, phenomena of double refraction in the shells of certain diatoms, as, for instance, in *P. angulatum*, and his observations have since been confirmed by Valentin.† The double refraction, according to v. Mohl, is so powerful that under a Nicol's prism even the hexagonal points on the surface may be seen. It was these observations that suggested to the author that the appearances presented in the *Pleurosigma* valve might be due to siliceous crystals.

As this idea, as has been shown, is not maintainable, to what cause is the phenomena of double refraction to be assigned? There is no doubt of the correctness of H. v. Mohl's account as applied to dry valves, but when they are mounted in Canada balsam or other highly refracting medium the appearance is at once destroyed. There can be no doubt, therefore, that the phenomenon is due, not to double refraction, but to what the author terms *depolarization by refraction*, as is exhibited in one of Nobert's tests when seen through ground glass or through fine, crossed lines. The very faint appearance witnessed, more especially in the thicker diatoms, quite at the edge of the valve, even when mounted in balsam, the author explains on the supposition that their structure may be laminated, and consequently that the substance at different depths is in a condition of varying tension.

On Sagitta. By Professor Keferstein.

Professor Keferstein, of Göttingen, in his recently published 'Investigations on the Lower Marine Animals,'‡ has a short communication entitled "Some Remarks on *Sagitta*," of which the following is a translation.

Ovary.—In specimens of a *Sagitta* about 9 mm. in length, which was taken pretty frequently at St. Vaast, and which agrees for the most part with that so admirably described by R. Wilms, and denominated by Joh. Müller *S. setosa*, I found

* 'Botanische Zeitung,' 1858, p. 10. Poggendorff's 'Ann.,' 1859, Bd. 108, pp. 179—185.

† 'Die Untersuchung der Pflanzen-oder der Thiergewebe in polarisirtem Lichte,' 1861, p. 203.

‡ Forming Part 1 of vol. xii of Siebold and Kölliker's 'Zeitschrift für wissenschaftliche Zoologie,' 1862.

the ovary in every respect just as Wilms has already described it. Along its outer side is the thickened ovarian wall, and within this is excavated the oviduct, which probably possesses an internal orifice in front, and, posteriorly, opens externally in the well-known papilla.

Krohn has likewise observed this canal in all sexually mature individuals; he regards it, however, not as an oviduct, but as a seminal receptacle. I found this canal almost always filled with the long, thread-shaped zoosperms, which projected in a tuft from the papillary orifice of the ovary, and thus, like a probe, indicated the opening of the lateral canal in this papilla. At its anterior end I could, indeed, directly make out no entrance of the canal into the ovary, and am, therefore, unable to determine whether it be an oviduct or seminal receptacle, though the former seems to me the more probable, especially because I almost constantly found within the ovary several very large eggs, which appeared to be undergoing development. One must infer from this an internal fecundation of the ova; but the observed condition of the eggs agreed so little with the history of their development given by Gegenbaur, that I dare not venture any positive opinion.

Setigerous tufts.—As Wilms and Krohn have already pointed out, little bundles of fine, stiff, often very long hairs, occur on the surface of *Sagitta*, when uninjured. Usually these setæ are pretty regularly disposed behind one another in a dorsal and ventral series, and the fins are placed between these series along the body, so that at first sight one is reminded of the setigerous tufts of the Annelids. But the setæ of *Sagitta*, as Krohn has already stated, and as I have particularly observed in *S. serrato-dentata*, Kr., of Messina, rests on the epidermis, composed of rounded clear cells, ·037 mm. in length, with granular contents, which is raised up into an eminence beneath each setigerous tuft. The setæ are merely outgrowths of the membrane of one of these epidermic cells.

If one of the above epidermic eminences be examined with a high magnifying power, it seems to be traversed from its base to the setigerous cells by a fibrous tract, which can be traced backwards to the so-called ventral saddle, in which these fibrous tracts terminate in a radiate manner. Krohn, as is well known, has declared this (often very large) ventral saddle to be a nervous ganglion; in regard to which point I myself, with W. Busch, cannot doubt that this excellent investigator has fallen into error, for the ventral saddle lies outside the muscular coat of the animal, and stands in no connection with the brain which can be perceived within the head. But what significance should be ascribed to this ventral saddle, I am not able to say; and one looks in vain for any hint with reference thereto from the development of *Sagitta* as observed by Gegenbaur.

Eyes.—The two eyes, as is known, are placed in the integument on special rounded ganglia, which, by means of a nervous filament, are brought into connection with the cerebral ganglion lying in front of them. The eyes consist of a quadrangular mass of pigment, which probably conceals a retina within, and, externally, supports on either side about four or five small, oval, brilliant, crystalline cones; on the lateral aspect of the pigment spots, however, the crystalline cones are wanting, or, at least, are reduced to two smaller ones in front and posteriorly. I have not observed the contour which Wilms remarked on this outer side of the pigment spot, and was inclined to regard as a cornea or lens; and to me, with Leydig, it appears probable that the structure of the eye of *Sagitta* approximates, on the whole, to that of the *Arthropoda*—perhaps of the *Daphnidæ*.

A few figures accompany the original paper. It will be remembered that our volume for 1856 contained a full abstract of what was then known of the structure of *Sagitta*, together with references to the works of other writers.* This was followed, in 1859, by a translation of Gegenbaur's 'Memoir' on the development of the same organism. More recently, Gegenbaur ('Grundzüge der vergleichenden Anatomie,' 1859, p. 138) has reiterated his former views concerning the systematic position of *Sagitta*, by founding for its reception a distinct class, OESTELMINTHES, between the *Nematoidea* and *Annelida*.

* To the list there given add Gervais ('Ann. Franç. et étrang.,' 1838, p. 127); Œersted ('Vedens. Med.,' 1849, p. 26); J. Müller ('Archiv,' 1847, p. 158); Gosse ('Tenby,' 1856, p. 175); and Leydig ('Lehrbuch der Histologie,' 1857, p. 261).

NOTES AND CORRESPONDENCE.

Cell for viewing Entomostraca.—The motions of many of the Entomostraca are so rapid and fitful that restraint must be adopted to observe them; but this, in the case of many of them, prevents a good view from being obtained of their wonderful coverings, and also of their peculiar movements. Having a strong wish to see them entirely at liberty and to watch the peculiar mode of opening and shutting of the carapace, I contrived a small cell, which so completely answers the purpose as I hope may justify my bringing it under the notice of those interested in those exquisite little creatures. The cell is formed out of a piece of glass tube, $\frac{3}{16}$ths of an inch in diameter and $\frac{1}{8}$th of an inch deep, and it cemented on the centre of an ordinary glass slide by marine glue applied to the edges of the piece of tube, so that the cell is quite transparent, and holds just a drop of water, but leaving ample room for the active little creatures to move freely about. This tiny cell is quite within the field under a two-inch object-glass, which is generally sufficient to observe all their motions; but should the inch be required, so much of the cell remains within the field that the slightest touch of the stage movements suffices to keep the object constantly in view. By this little contrivance I have been enabled to view *Daphnia* and *Cypridia* in a way that I was never able to do before, when I had to restrain their motions in an ordinary live box.—JOSEPH DAVISON, Newcastle-upon-Tyne.

Vegetable Amœboid Bodies.—In Hofmeister's work on the Higher 'Cryptogamia' (Ray Society, 1862), pp. 162-3, occurs the following passage, which possesses much interest in regard to the amœboid conditions of vegetable cells. Speaking of the spore-mother-cells of *Phascum cuspidatum,* he says, "Individual points of the primordial utricle sometimes exhibit slow expansions and contractions similar to those of many of the inferior animals; for instance, the smaller Amœbæ. It is especially in such cases that the delicate mucilaginous membrane which encloses the cell-contents may be most clearly observed." This observation is not accompanied by any reference to other observers, and, therefore, being independent, is of more value, especially coming, as it does, from so accurate and careful a writer. It agrees with the same condition which I have before pointed out in this Journal, as occurring in the mother-cells of the gemma of *Volvox globator*.—J. Braxton Hicks.

The Microscope in a Police Court.—It is not often that we have to report the proceedings of our police courts. The following case, however, conveys so obvious a lesson that we give it for the benefit of our readers.

Griffiths *v.* Stevens.—The plaintiff, a pharmaceutical chemist, sued the defendant, an auctioneer in King Street, Covent Garden, for the sum of 17*s.*, under the following circumstances. The plaintiff had attended a sale in King Street, in December last, and bought lot 418, described as "a two-inch achromatic, by Smith and Beck." It was afterwards found that the glass was not one of Smith and Beck's, but only a single lens, and comparatively worthless.

Mr. A. W. Griffiths deposed that he had attended the defendant's sale on the 20th of December, and had purchased the object-glass produced for the sum of 17*s*. He had since ascertained that the glass, although put into a genuine box of Smith and Beck's, was spurious, and of little value. Had applied to the defendant, who referred him to a Mr. West, of the Strand, optician, as the person who had sent the object-glass for sale; but he (plaintiff) had failed to obtain any redress, and had therefore instituted the present proceedings. On the day when the summons was first made returnable, Mr. Beck, of the firm of Smith and Beck, had attended to give evidence but was not now present.

Mr. J. Bland, pharmaceutical chemist, stated that he possessed a microscope of Smith and Beck's make, and could say, from his knowledge of their style of work, that the glass was not of their manufacture; it was only a single lens, whereas it should, if genuine, have been a combination of four or six lenses arranged in the same tube. The witness was about to mention something said by Mr. Beck in his presence, but was stopped by the learned judge, who said he could not receive matter of conversation as evidence.

The defendant being called upon, stated that no application was made to him on the subject until after he had settled accounts with the person who had sent in the glass for sale. It had been given out in the room at the time of the sale that the glass was not Smith and Beck's, but he chiefly relied on the conditions of sale printed on the catalogue, one of which was to the effect that "the lots were to be taken away with all faults and errors of every description," and which, he contended, relieved him from all liability.

Mr. Bland being recalled, said, in answer to his honour, that he had been present at the sale, and had himself, when the next lot (also described as by "Smith and Beck") was put up, called out "the box is Smith and Beck's, but the glass is not." He had heard no such remark by any person with reference to lot 418.

His Honour said that the condition of sale on which defendant relied, although it might have protected him as an accidental *bona fide* error, was clearly of no force in case of fraud; in the present instance here was an article explicitly described in the catalogue as "an achromatic by Smith and Beck," and put up in one of their genuine boxes, with their name and address engraved upon it, so as to deceive any ordinary person. He thought it would have been more satisfactory if some one from Smith and Beck's had been in attendance; but looking at the fact that the plaintiff's witness had given evidence that he was acquainted with such matters, and that the article was not what it was described to be, the plaintiff was entitled to recover. He would, however, if the defendant desired it, adjourn the hearing of the case at his expense, for the production of further evidence.

The defendant declined to accede to this suggestion, and judgment was given for plaintiff, with costs.

PROCEEDINGS OF SOCIETIES.

Microscopical Society.

January 14*th*, 1863.

R. J. Farrants, Esq., President, in the Chair.

Sir James Tyler, T. S. Scott, Esq., John Povot, Esq., Dr. G. Ciaccio, and Mr. Alfred Sanders, were balloted for, and duly elected members of the Society. Verbal communications were made by the Rev. J. B. Reade, "On a Mode of Preparing Desmids, and on the Microscopic Structure of a Fragment of African Sculpture;" and by H. Deane, Esq., "On the Fibres and Smut of Wheat."

February 11*th*, 1863.

Anniversary Meeting.

R. J. Farrants, Esq., President, in the Chair.

Reports from the Council, on the progress of the Society, from the Auditors of the Treasurer's accounts, from the Library and Instrument Committee, were read.

The President delivered an address, showing the progress of the Society during the past year, and also of microscopical science during the same period.

In his address the President announced that Mr. T. Ross had signified his intention of presenting the Society with one of his best microscopes, with all the recent improvements, and that Messrs. Powell and Sealand and Smith and Beck had also signified their willingness to let the Society have their object-glasses on very favorable terms.

The thanks of the meeting were returned to Mr. Ross and to the other instrument makers mentioned for their very liberal offer.

The Society then proceeded to ballot for Officers and Council for the year ensuing, when the following gentlemen were declared duly elected:

As President—Charles Brooke, Esq.

As Treasurer—C. J. H. Allen, Esq.

As Secretaries— { George E. Blenkins, Esq.
F. C. S. Roper, Esq.

Four Members of Council:

W. H. Ince, Esq.
J. R. Mummery, Esq.
Charles Tyler, Esq.
Robert Warington, Esq.

In the place of—

A. Brady, Esq.,
Jabez Hogg, Esq.,
E. G. Lobb, Esq.,
Tuffen West, Esq.,

who retire in accordance with the regulations of the Society.

The thanks of the meeting were returned to R. J. Farrants, Esq., for his services as President during the past year.

March 1*st*, 1863.

Charles Brooke, Esq., President, in the Chair.

E. C. Northcott, Esq., J. D. Allcroft, Esq., G. Torr, Esq., and J. De Castro, Esq., were balloted for, and duly elected members of the Society.

The following papers were read:—"On some new Species of Diatomaceæ," by Dr. Greville. "On the Formation of Cartilage," by Dr. Beale.

The Literary and Philosophical Society, Manchester.

Microscopical Section.

15*th December*, 1862.

Mr. J. G. Lynde, F.G.S., M. Inst. C. E., in the Chair.

Mr. Alfred Fryer was elected a member of the section.

Captain Moodie, of the R.M.S.S. *Canada*, presented two soundings taken off Nova Scotia. Captain Thomas Millard, of the barque, *First of May*, presented specimens of anchor mud from Montego Bay and the harbours of Kingston and Port Royal, Jamaica; also a sounding from the banks of Newfoundland.

The Chairman stated that he was led to pursue Dr. Robert's suggestions on the use of magenta dye in examining tissues. From experiments made since the last meeting of the section, he finds that the dye has no power to colour living tissue, whether animal or vegetable, but that as soon as life is extinct the action of the dye commences. He is continuing the experiments, which are of a most interesting character, and he hopes to lay the result before the next meeting of the section.

Mr. Leigh considered it probable that so long as vital action continued, ordinary endosmosis could not take place.

Mr. Mosley said that Mr. Hepworth had frequently tried magenta for injections, and the results were not satisfactory, as the colouring matter diffuses itself through the whole of the tissues, giving an appearance of dyed flesh rather than that of injected preparations. This appears to confirm the preceding observations, and to account for the accumulation of colour where the integument is thickest, by means of which Dr. Roberts discovered the spot on the red blood-discs, as announced at the previous meeting.

Mr. Leigh drew the attention of the section to the adulteration of size as a cause of mildew in cotton goods.

Mr. Watson named the investigations made by Mr. Thompson about twenty-five years ago, as to the cause of mildew in madder purple-printed cottons shipped to hot climates. It was attributed to the starch employed in finishing the goods, which, acted upon by moisture, heat, and pressure, had given rise to an organic acid which discharged the colour.

Mr. Hurst described his experience of mildew on printed cottons and upon dyed fustians at Gibraltar and Calcutta. In most cases it appeared in spots and round patches, which affected the colours. On the fustians, he had no doubt, it was caused by the growth of a fungus, as the surface of the spots was sensibly raised.

Mr. Mosley considered there might be several kinds of mildew; that upon the fustians might be attributed to the bone size with which those goods were generally finished, and known by the characteristic smell. Mr. Mosley also exhibited a pattern of gray calico, which had become discoloured and quite rotten in irregular patches, from mildew; it had lain for some time in a damp place, under pressure; there was this peculiarity about it, that the coloured patches whilst damp were quite tender, but on exposure to the air and drying the cloth had recovered its strength.

Mr. Heys remarked that twenty years ago he was engaged in the manufacture of fine muslins; it was usual to soak the weft in soap suds, to facilitate the weaving; and it was found the cloth was most liable to mildew during hot, close, summer weather, and the greater the quantity of goods heaped together the more rapidly would mildew set in. The flour from which the size was made was always the best that could be purchased.

Mr. Heys exhibited mounted specimens of the fibres of the *Zostera marina*, and stated that, as the fibre is considerably finer than the finest Sea Island cotton, it might probably be of use in the manufacture of fine muslins for ladies' dresses, if it were possible to obtain a supply, and separate the fibre from the plant by machinery. Mr. Heys also exhibited mounted specimens of Queensland cotton, lately sold at 5*s*. per pound; the fibre is very regular in size, and much more cylindrical than other cottons; also several specimens from ripe and unripe pods, and Mr. Heys expressed the opinion that great advantage would arise from a regular and careful examination of cotton-fibre taken fresh from the plant through every stage of growth.

19*th January*, 1863.

Mr. Joseph Sidebotham, Vice-President of the section, in the Chair.

Captain Isaac Tessyman, of the ship *Ann Mary*, presented four soundings taken off the coasts of Patagonia, Singapore, Malay Peninsula, and at Algoa Bay, during his late voyage to San Francisco, Singapore, &c.

Captain J. B. Husband, of the ship *Mutlah*, presented three soundings taken off Orissa, and the Black Pagoda on the coast of Bengal.

Mr. Latham presented mounted slides of the skin of the *Muræna guttata*, cocoon of silk worm, and cuticle of Gladiolus.

Mr. John Slagg, jun., presented mounted specimens of floats and ovaries of *Ianthina;* shells of ditto; berry of *Fucus natans* covered with Membranipora; and *Criseis aciculata*, a Pteropod.

Mr. John Hepworth referred to the mildew mentioned in the proceedings of the previous meeting, which had been observed at Gibraltar on fustians stiffened with bone size, and stated that he had noticed a peculiar fungoid growth upon mounted sections of bone, and that it would be desirable, if possible, to compare them.

Mr. John Leigh, M.R.C.S., read a paper "On the Use of Dialysis in Microscopical Investigations."

After describing the researches of Professor Graham, the present Master of the Mint, and explaining the nature of the division into two classes of all natural bodies, namely, into crystalloids and colloids, their affinities and means of separation, the author proceeded to describe some curious bodies found in cleaning out a steam-boiler, which have almost exactly the external form and internal structure of the concretions formed by Mr. Rainey, and figured in Dr. Carpenter's work on the microscope, third edition, p. 769. They are composed chiefly of carbonate of lime and organic matter, aggregated in the presence of the aluminous colloidal mud in the boiler, and are, on a large scale, a singular illustration of Mr. Rainey's experiments. The author then enlarged upon the advantages of this method of investigation to the microscopist and chemist, who may go hand in hand in the examination of the crystalloidal constituents of organic bodies. "The microscopist (says the author) will often be able to direct his fellow-worker into new channels of research. A careful study of minute crystals, with accurate measurements of their angles and observations on the effects of polarized light, may, to speak medically, lead to an accurate diagnosis of them, as is afforded to the tests of the chemists, to whose larger operations they may be referred for further analysis. Dialysis affords us the means of separating the saline constituents of the juices of plants from the salts fixed in their tissues, and similarly in regard to animal bodies. By one or more dialytic operations on a limited scale the crystalloids of any vegetable juice may be obtained in solution of great limpidity, and by careful evaporation over a water bath they will crystallize out in a state fit for examination." Mr. Leigh concluded his paper by the quotation of some apposite remarks by the late Professor Johnstone, of Durham, and exhibited the small trays he uses in his experiments, consisting of a double rim of gutta percha securing a disc of parchment paper in the form of a sieve; also specimens of the mulberry-shaped nodules found in a steam-boiler, as before named.

The Chairman said that for minute experiments he had used the parchment paper in the form of a filter.

Mr. Dancer stated that porous earthenware could be advantageously used as a dialyser.

Professor Williamson indicated a number of subjects upon which dialysis would probably throw light, both in vegetable and animal physiology. He especially dwelt upon the phenomena of calcification and silicification, illustrating his remarks by reference to what occurs in the formation of calcareous and silicious growths in the colloid sarcode of sponges and polypifera, in the development of the dental plates of the teeth of Echinus, in the calcification of the derms of the crustacea, the shells of mollusca, the scales of fishes, and in the chondriform and membraniform bones and teeth of the vertebrate animals. The professor suggested that a natural process of dialysis probably underlay all these formations. He specially called attention to the close resemblance subsisting between the primary spherical and concentric granules seen in the derms of the crustacea, in the scales of cycloid and ctenoid fishes, in the outermost layers of many teeth, and the artificial concretions produced by Mr. Rainey, to which Mr. Leigh alluded in his paper. Professor Williamson further suggested for inquiry, how far the structureless basement membrane seen underlying the calcareous layer of many calcified structures (*e.g.*, the pulp-membrane of the tooth), played some part equivalent to the parchment dialyser of the Master of the Mint.

Mr. Mosley read extracts from a report to the Cotton Supply Association, of a microscopical examination of a sample of cotton supposed to have some peculiarities. On comparison with good American cotton, it was found to contain a greater proportion of round and partially flattened filaments, all more or less twisted, but full and well developed; the polarized colours were more bright and vivid, all indicative, he considered, of strong and vigorous growth in a congenial soil, and careful gathering when the pod was at its highest stage of development. The fibres varied in size, from flattened ribbons of $\frac{1}{800}$ of an inch broad to cylindrical fibres of $\frac{1}{1500}$ of an inch in diameter, the variation being due mainly to the amount of compression of the cylinder rather than to actual difference in bulk. The staple measured from 1 inch to $1\frac{1}{4}$ inch in length. The contrast with some inferior cottons was strongly marked, as regards their twisted, flat, tape-like appearance, and faint polariscopic colouring, which he attributed either to weakly growth or to having been picked from over-ripe pods, when the fibre had become dry and sapless. Too little is, however, known to form an exact opinion; dissection of buds and pods in all stages of growth would be necessary for a full and exhaustive investigation of the subject.

In reply to a question from Dr. Robertson, Professor Williamson stated that, like all vegetable hairs, the cotton-fibre in its early stage is unquestionably cylindrical.

Mr. Sidebotham exhibited a convenient and effective form of binocular microscope, by Mr. Dancer, suitable for naturalists and others.

Mr. Brothers exhibited a mounted slide of Foraminifera, and a drawing of *Coleochœte scutata*, a minute fresh-water alga.

Mr. Whalley exhibited *Trichoda lynceus*, marine infusoria; also an objective, $\frac{1}{25}$ of an inch focus, by Messrs. Powell and Lealand.

16*th February*, 1863.

Mr. Joseph Sidebotham, Vice-President of the Section, in the Chair.

Captain Fletcher, of the ship *Tigris*, presented a portion of harbour mud from Singapore, and five soundings from the coasts of Java and Sumatra.

Mr. R. D. Darbishire presented specimens of mud and fossil shells (received through Dr. P. P. Carpenter), from the post-pliocene or latest tertiary deposits at Logan's Farm, Mile End Quarries, near Montreal, Canada, described by Sir C. Lyell's 'First Travels in North America,' vol. ii, p. 135, and in papers by Dr. J. W. Dawson, in the 'Canadian Naturalist,' 1858 and 1859. Mr. Darbishire, in a note to the Secretary, stated that one of the peculiarities of the deposit is that it seems to have been formed in a quiet hollow; spicula of sponges are found in position, as if the sponge had grown, and been quietly buried on the spot. Amongst other fossils are many kinds of Foraminifera and a siliceous, close-textured sponge, referred to Tethea, of the species Logani, which is now found in water from the tide line to 200 fathoms deep. Mr. J. H. Nevill undertook to examine and report upon the specimens.

Mr. H. A. Hurst presented a copy of Part iv, vol. xii, of the 'Journal of the Agricultural and Horticultural Society of India,' published at Calcutta, containing the prize essay "On Cotton Cultivation in India from Foreign Seed," by Dr. J. Shortt, F.L.S., Zillah Surgeon, Chingleputt, for which the prize of 1000 rupees and the gold medal of the Manchester Cotton Supply Association were awarded.

Mr. Hurst read a paragraph from page 499, relating to the early stage of the cotton-pod, which, bearing on points lately in dispute, is given entire:

"On examining a cotton-pod soon after the ovary has been impregnated (which is known by the change in colour and the fading of the petals or flower leaves, or corolla), it is found to contain a number of seeds, according to its particular variety. If a single seed be separated and examined by the naked eye, nothing is visible; but when seen through the microscope, it is found covered with a villous coat, formed apparently of elongated cells, joined end to end. These are filled with sap. The young seed itself is somewhat pear-shaped, and resembles in miniature some of the China candied fruits, with the frosted crystals of sugar covering it. On letting out the contents of a single cell, it is found to consist of granular cells, containing a centro-lateral nucleus. On examining a pod between three and four weeks old, the seed still retains somewhat of its pyriform shape, and appears quite shaggy; the fibres, tapering to a point at their free ends, resemble hollow cylindrical tubes, filled with fluid and vary in length; and on submitting a single fibre compressed between pieces of glass to the microscope, the flattened surfaces become distinctly visible. Again, on substituting a mature fibre before it gets dried, the filament is found to consist of tubular hairs, which are now quite cylindrical. After the dehiscence of the mature capsule, by the contraction and separation of its valves, the wool becomes dry from exposure. A filament now placed under the microscope is found to resemble a flattened piece of tape twisted upon itself, and apparently formed of an extremely thin and transparent membrane, interspersed with dark, granular matter, which, after a certain time, disappears in some of the varieties."

Mr. J. G. Lynde, F.G.S., M. Inst. C.E., read a paper "On the Action of Magenta upon Vegetable Tissue," in which he described a series of experiments upon cuttings of Vallisneria, immersed in a solution of that dye in glass cells under the microscope, with its effects upon the circulation and the cell contents of the plant. He found that so long as vital action continued, the cell-walls and moving chlorophyll retained their green colour; but the injured cells were immediately deeply reddened, and their contents gradually acquired the same colour, the intensity of which was in proportion to the thickness or density of the tissue. Between the cell-walls it would appear that there exists an intercellular membrane, devoid of vital action, which becomes rapidly coloured whilst the circulation continues active. On the inner surface of the cell-wall, whilst rotation is going on, the author observed a luminous stratum, suggesting the action of cilia; but in every observation, as the dye permeated the tissue and the circulation ceased, the inner cell-wall became covered with irregular markings, either corrugated or having raised excrescences, scarcely alike in any two cells; in no case were the markings visible until the rotation had ceased, and they had the appearance which would be produced by cilia* falling against the cell-wall in all positions upon the suspension of vital action.

The chlorophyll-vesicles appear in three forms—in a gelatinous sac or mass, rotating altogether in the cells; as independent vesicles, apparently homogeneous in their structure, rendered opaque by colouring matter; and lastly, as independent vesicles, somewhat increased in size, of a pale-green colour, and almost transparent, containing nuclei, one, two, or three in number, which, in reality, appear to be smaller vesicles within the parent, similar to *Volvox globator*, without rotatory motion. The chlorophyll-vesicles appear to resist the action of the magenta for some time after the rotation has ceased, indicating a vitality to a certain extent at least independent of that in the cell. In some of the experiments a few of the cells assumed a purplish colour, whilst in the adjoining cells the circulation was active, and the chlorophyll green; in those purple cells the chlorophyll appeared to be decomposed, and the cell nearly full of very minute dots, swarming like the granules in *Closterium lunula;* upon this point the author offered no opinion. The observations were made with $\frac{1}{5}$th and $\frac{1}{8}$th objectives, and the paper contained minutiæ of several experiments, such as the hours of observation, temperature of the room, and other particulars.

Dr. Roberts observed that Mr. Lynde's remarks upon the separate vitality of the cell and cell-contents were very suggestive; he had noticed that fresh blood-discs (for instance, from a pricked finger) were not immediately affected by magenta, but that time was required for the dye to permeate the tissue.

Mr. Neville exhibited a new form of cell, cut out in card-

* Eminent microscopists do not entertain the idea that the circulation in Vallisneria is due to ciliary action. "This appearance is decidedly affirmed by Mr. Wenham to be an optical illusion." (See quotation by Dr. Carpenter, 'The Microscope and its Revelations,' 3rd ed., p. 408, from Dr. Branson and Mr. Wenham, 'Quarterly Journal of Microscopical Science,' Vol. III, 1858, pp. 274 and 277.) This opinion was possibly formed upon observations made during vital action, and may be modified upon examination of the (supposed) dead and dying cilia, rendered visible by the action of the magenta dye.—*Secretary Mic. Section.*

board, containing seven divisions for seven different objects; it is very suitable for Foraminiferæ, Diatomaceæ, &c., and may contain seven species, to economise space in cabinets and facilitate exhibition. The perforations are about a quarter of an inch in diameter, and made with a saddler's hand-punch; the disc is then covered with black varnish, and secured to the glass slide.

Mr. J. B. Dancer exhibited new cells for opaque objects of various sizes; they are made of a composition, and cast in a mould.

Mr. J. G. Dale exhibited, with the polariscope, crystallized films of picrate of aniline and of santonine; they were rich in colour, and some of the forms are believed to be new.

Southampton Microscopical Society.

The second annual soirée of the Southampton Microscopical Society was held in the new Hartley Institution, on the evening of Thursday, December 11th. The members meet once a month, when a paper is read, illustrated by specimens, and once annually the society makes a public demonstration in this way of its year's work, in order to increase the taste for microscopical science in the town and neighbourhood. This gives an opportunity also for bringing together on the common ground of science many who do not generally mix together socially—the gentry of the town, the magistrates, the town council, the professional and commercial classes, meet together in a large evening party. The new Hartley Institution is a noble building, and its library, class rooms, museum, and theatre, brilliantly lighted and filled with a well-dressed crowd, the tables covered with a large number of excellent microscopes, surrounded by ladies full of curiosity and interest, was a gay and lively sight. About 1200 visitors were present during the evening, which seemed to be much enjoyed by all.

The following is the programme of the evening's proceedings:

Messrs. Smith and Beck exhibited several binocular microscopes, their beautiful transparent injections, especially one of the brain, being a source of great attraction.

Mr. S. Highley also exhibited specimens of his microscope, and a selection of photographic views of microscopic natural history and other subjects by the oxyhydrogen lantern, which he is now engaged in bringing out for educational purposes. Some of the views were from photographic negatives by Dr. Maddox, of Southampton.

The address was delivered by the President, Dr. Bullar.

He began by expressing the pleasure the members felt at seeing their friends again at their second annual soirée, the object of which was, not to teach microscopical science, but to excite the curiosity of those who have no knowledge of it, and who are unaware of the pleasure it affords. As so many ladies were present, he suggested that it was a branch of science they may both delight and excel in, for it deals with the most delicate objects, requiring the finest touch and handling, all of which display exquisite workmanship, and many consummate beauty. He directed attention to some enlarged drawings made by two ladies from the objects under the microscope, which, for accurate drawing and taste, could not well be exceeded; and he remarked that if ladies with leisure would devote the same patience they exercised in fancy work to microscopical investigations, not in a desultory way, but following up one subject, they might add to our discoveries as well as to their own interest in life. And if ladies did not pursue it themselves, they might create a taste for natural history in their families, and thus become the mothers of the minds of future naturalists. Carlyle described Dr. Arnold's house as a "temple of industrious peace;" and it is in such temples, with their guardian priestesses, that tastes are best cultivated, which, in after life, have the pleasantest recollections; and, as age advances, the mind, interested in all kinds of truth, remains fresh and young, a source of comfort to itself and of light and joy to all around it. After directing attention to some of the microscopical specimens of most interest to such a company, Dr. Bullar thanked the town council for lending the handsome and commodious rooms of the Hartley Institution for the legitimate purpose of increasing taste in science in Southampton, and he thus concluded:—"Living as we are amongst so many new wonders, in an age which paints in an instant our portraits by the light, sends our messages by the electric force with the velocity of a wish, carries our bodies and our merchandise by consummate mechanism, moved by steam, over earth and sea, with the speed of the storm and the certainty of time, and brings and concentrates with the same rapidity, from every portion of the globe, its freshest news for our daily reading—which, by a refined optical chemistry, discovers, by the colours of light, the actual mineral constitution of the sun—with the telescope not only discloses, but photographs the mountains and the valleys, the extinct volcanoes, and the sterile rocks of the moon, and resolves the distant night clouds of light into systems of starry worlds—and, in the other direction, looking downwards instead of upwards, by our microscope reveals new worlds of living beings in the water we drink and in the dust we tread upon—living amidst such wondrous realisations of the scientific hopes and dim anticipations of the most sanguine philosophers of former days, these marvels seem to us so common that we are apt to forget our high privileges, and not sufficiently to dwell upon and to rejoice in the fuller life and more extended knowledge and wider range of beauty that is opened to us. For with such advantages lavishly bestowed on us, we only need the common use of our faculties—the eyes awake to see, the mind attentive to observe, the heart open to feel, this wondrous world of ours—in order to live and breathe "in an ampler æther, a diviner air," than a world of lower pursuits or amusements affords. And thus may we not, from the lessons of science, imbibe an antidote to that critical habit which, studying imperfections and indulging in discontent, makes the mind equally disagreeable to itself and to others? Science gives us a wiser lesson. She also studies imperfections, but not to grumble at them, not to feel uncomfortable or discontented, but to discover their meaning and to find in apparent irregularities the proof of the working of the same law which, in happier circumstances, results in perfect symmetry. We have, however, no wish to overrate science, and especially its popularisation. There are higher aims than those of mere science, which can never radically improve the race nor give to man the happiness he needs. Christianity alone can do this. But science cannot be divorced from Christianity. It was one of the great objects of Lord Bacon in the advancement of science, to show by what discipline the mind may be freed from its imperfections so that she might see truth in clear outline, uncoloured and undistorted by passions, prejudices, and habits. To observe nature and to discover her "open secrets" requires (as Bacon taught) a mind as true and clear as our present glasses. And the spirit of truth which Christianity gives under her own conditions must be the very same spirit which science requires; and he must have (other things being equal) the clearest insight into her laws who has that simple, unbiassed love of truth which accompanies singleness of purpose and purity of heart.

ORIGINAL COMMUNICATIONS.

Some Remarks *upon* Light. A Paper read before the Microscopical Society of Newcastle-upon-Tyne. By B. S. Proctor.

It can scarcely fail to have struck every microscopist that the white materials of everyday life, when submitted to the keen gaze of microscopical examination, display bright reflecting surfaces and clear transmitting substance; that black substances are also shining, though in a less degree and having less transparency; and that the most opaque materials transmit more or less light when in thin section.

Having noticed such commonplace facts, I was led to ask myself—

What is the difference in the appearance of transparent and opaque white powders? Are white organic materials ever opaque?

And I entered the same on a list of subjects which I keep for future examination. These questions had not long been there before they were followed by another entry.

Are all opaque substances black when in a fine state of division, as copper, iron, silver, platina?

How far is blackness coincident with opacity and heterogeneousness or division?

How far is whiteness coincident with transparency and heterogeneousness or division?

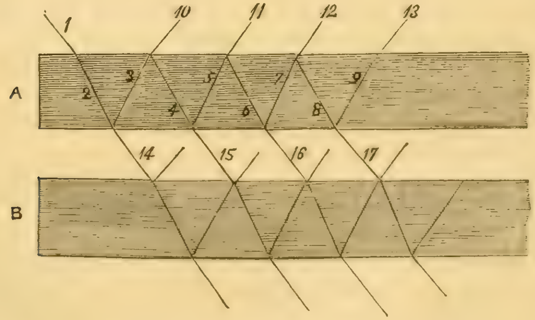
Is anything opaque? If not, what is the nature of the phenomena of proximate opacity, black, white, and coloured?

Having these questions entered on my list, and kept in my mind by occasional reference to the same, they have suggested a variety of thoughts and observations, which I now propose to present to you, hoping that their enunciation will afford you a per-centage of the interest which their elaboration has afforded myself.

In the pursuit of physical science, we can scarcely ask ourselves for an explanation of any simple phenomenon without being led into another question and another; each step opens out new paths on every side, all inviting us to a journey of discovery. I began by asking, Is every white body transparent? But where shall I end? As white as fine linen, flour, chalk, as white as snow. They are all poor comparisons, dull examples, nothing to be compared to many of the chemical precipitates. Precipitated chalk far outshines the natural varieties, and fine qualities of carbonate magnesia outshine it. Of a great number of substances I have compared, Howard's carbonate of magnesia is the whitest, and microscopical examination indicates that it consists of clear, colourless particles, but very minute. White lead consists of particles equally minute, and also transparent, but of a yellow-brown colour by transmitted light; consequently, when seen in bulk, it appears of a less pure white. Why should not magnesia be used as a pigment? A painter will tell you it has not sufficient "body;" and now comes the question, What is "body," and why has one white powder more than another? Before we can give an intelligent answer to this question, we must take into account the laws which govern the transmission, absorption, and reflection of light.

Light falling obliquely upon a plate of glass is partly reflected, partly transmitted, until it comes to the under surface of the glass, where it is a second time partly reflected and partly transmitted; the reflected portion again meeting the upper surface, is subjected to further division into reflected and transmitted light; the reflected portion meets the lower surface, is turned up again, and so *ad infinitum*.

In the diagram we have roughly sketched the path of a ray.



A and B are sections of glass plates: 1, is the incident ray; 2, 3, 4, 5, &c., indicate the reflections it undergoes within the substance of the glass, the intensity of the beam becoming rapidly less from the loss it sustains, by a portion being transmitted at each reflection; 10, 11, 12, and 13, indicate the portions transmitted through the upper surface of the glass from the reflected rays, 3, 5, 7, and 9, respectively; 14, 15, 16, and 17, indicate the portions transmitted through the lower surface of the glass from the primary ray 2 and the rays 4, 6, and 8, respectively; the ray 14 describes a path in B similar to that described in A, by the other portion of the primary ray, but at its second reflection it is joined by the ray 15, and at its fourth by the ray 16. Its second reflection is accompanied by a transmission of a portion through the upper surface of B, which then re-enters A, undergoing again the same series of transmissions, reflections, and passages from one plate to the other, an indefinite, if not an infinite number of times; and if, instead of two plates there were twenty, the same would go on in a much more complicated series.

Only a small portion of light finding its way through the whole series of plates, and all the remainder being reflected or absorbed during its many passages backward and forward, the proportion of light reflected at each surface, compared with that which is transmitted at the same, depends upon the amount of refraction which the transmitted portion undergoes; and the amount of refraction depends upon the angle of incidence, and the comparative densities of the glass and air, or other media with which we are dealing. If instead of air between the plates we have water, there will be less refraction at each surface, because of the less difference in the densities in the two media; consequently, there will also be more transmission and less reflection; the bundle of plates will become, as a whole, more transparent.

We have here three bundles of glass plates; in one there is air intervening, and you will observe it has considerable opacity, and reflects much light; in the second there is water between the plates, and it is more transparent, and reflects less light; the third, in which spirit of turpentine replaces the air, is so transparent, and reflects so little light from the interior plates, that we might almost suppose it a solid block of glass. I have been speaking of the action of the *surfaces*, but every plate, however thin, consists of something more than two surfaces, and the substance which intervenes exerts what is called an absorbing power over the light as it passes through it. Though I do not think absorption a correct expression of what takes place, I will submit to the conventionality, and use it till something more correct is adopted. Supposing the bundles of plates to consist of a countless number, with air intervening, we have a considerable amount of light *reflected;* the light which penetrates the series becomes rapidly less; from the effects of reflection and absorption, it becomes at a given depth quite inappreciable. We replace the films of air by water; less light is reflected, as has been explained, the light is transmitted more freely, consequently it descends to a greater depth before it becomes inappreciable. If the water is replaced by Canada balsam, the reflection is again diminished, while the transmission is facilitated; and this takes place even though the balsam absorbs more light than the water, and the water more than air; but it is self-evident that if the reflecting power had continued the same, while the absorbing power had increased, there would have been a diminution both in the reflected and transmitted light. From these considerations we may state as a rule that, of bodies with plane surfaces, the reflecting power is greatest when the density is greatest, the laminæ thinnest, the intervening medium lightest, and the absorbing power of the two least. The reflecting power is least when the density is least, the substance homogeneous (free from lamination, &c.), and the absorbing power greatest. We have thus come to a conclusion regarding the first essential of a white or a black surface, viz., the circumstances regulating the amount of light reflected. A second essential is that all colours shall be reflected equally; for if one colour is reflected more than another, instead of having gradation from black to white, we have shades of the reflected colour. We will suppose, therefore, that our surface reflects all colours that fall upon it with equal facility, and now pass on to the third element. If the surface is a perfect plane, light falling on it is reflected at an angle equal to the angle of incidence, without suffering other changes in the character of the beam; consequently when the eye is directed to a given point on the surface, a line drawn from the surface at an equal angle on the other side of the perpendicular will point to the source of that light which enters the eye. If that source emits blue, red, or yellow light, blue, red, or yellow light will enter the eye, and the surface reflecting it will appear to have such a colour. How, then, can any smooth surface appear white when surrounded by objects of all colours? The fact is, *no* flat, smooth surface appears white when surrounded by objects of various colours.

If you have a surface of polished silver, it reflects and appears of the colour of the objects from which the reflected light emanates. If the silver, instead of being polished, is dead white, it apparently ceases to reflect the colours of the objects; but the microscope reveals the truth, that now the surface is not one smooth plane, but consists of an infinitude of curves, each reflecting all the colours of the surrounding objects; but so minute are these reflections that, to the naked eye, they cannot be separably distinguished, and the result is an impression of uniform colour; or if the various colours fall upon it in due proportion, its appearance is white: this is the nature of what takes place upon all white surfaces. You will say, How will it apply to such materials as porcelain, which have not a dead-white, but a polished-white, surface? In reply, I must direct your attention to the fact that in glazed porcelain there are two distinct reflections—that from the glazing is similar to that from the polished silver, but the glazing is transparent, the light passing through it falls upon matter which reflects light in the same condition as that which is reflected from the dead-white silver.*

Now let us return to the subject of "body," and we understand at once the difference between the white lead and the magnesia. They are both transparent in their individual particles, but the magnesia more so. They are both bodies possessed of considerable refractive power, but the lead more so. When air intervenes between their particles, the reflective power of both so much exceeds that of air that they are highly reflecting and very slightly transmitting; but the less absorbing power of the magnesia makes it the whitest—the more reflecting of the two. But when oil intervenes, as would be the case if they were used for pigments, the refractive power of the magnesia so nearly coinciding with that of the oil that much transmission and little reflection is the result, this constitutes what painters call want of body. But the lead so greatly exceeds the oil in refracting power that its reflective property is not much interfered with, and even with its greater absorbing power it reflects much and transmits little light, this being what painters call great body.

I have here specimens of carbonate of magnesia and white lead. You will observe that the magnesia, when dry and seen by transmitted light, consists of small particles which are transparent when seen singly, but look opaque where they are

* The manner of its reflection, however, being somewhat analogous to that of the bundle of plates, for the porcelain consists of transparent particles superposed upon one another, the various particles having different powers of transmission, reflection, and refraction, you will at once perceive that the same circumstances which changed the amount of one or other property in the bundle of plates will do the same in the porcelain. The more nearly the various parts have the same refractive power, the more light will be transmitted, the less reflected.

aggregated. The white lead is somewhat yellowish, evidently transparent, but not so clear as the magnesia.

By reflected light the magnesia is comparable to a fine sample of crystalline moist sugar, and the lead has an evident lustre and transparency, though in a less marked degree than the magnesia.

In those specimens mounted with balsam the magnesia is seen to be very transparent, consisting principally of roundish bodies, which have a dark centre when beyond focus and a bright centre when within focus, showing that the magnesia has less refracting power than the balsam. The white lead is very evidently transparent, and has bright centres when beyond focus, which are diffused when it is brought within the accurate focus, showing that the lead has greater refracting power than the balsam.

I have here two specimens of white lead, to illustrate the difference between that made by the usual troublesome process and that made by some of the more speedy processes which have at various times been tried, but have always fallen out of use again, because the precipitated lead was deficient in body, in consequence of its consisting of larger particles, as you will perceive. In commercial white lead the larger particles are aggregations of smaller ones, consequently look white and opaque, but in the precipitated variety they are solid crystals, clear and transparent.

I fear you will think I have occupied too much time with a matter more interesting to painters than to microscopists; but this is not the case, it is a subject of general optical interest, and specially connected with the mounting of microscopical objects. Why are sections of wood mounted dry if to be viewed as opaque objects, and in balsam if to be examined by transmitted light? What I have already said has answered the question. Why are starches best seen when mounted in gelatinous media? When examined dry, the great refraction the light undergoes in passing through them makes them appear black, except one small focus of light; if mounted in balsam (the refracting power of which so nearly concides with their own), their minute structure becomes invisible from the exceeding transparency imparted, according to the rule already pointed out. To overcome the lens-like power of the granules, without rendering their superficial markings invisible, we require to select a medium of refracting power between that of air and of balsam, and this we find in gelatine, &c.

I have here three mountings of tous-les-mois, in illustration of this fact. You will observe that which is in balsam has a dark centre while it is beyond focus, is uniformly light at focus, and has a bright centre when within focus, indicating that the balsam has a higher refracting power than the granules; with that mounted in the gelatinous medium, you will find that the effects of increasing and diminishing the distance from the object-glass are reversed, indicating that the starch has now a refracting power above that of the medium in which it is enveloped, and the markings on its surface are in this mounting much more distinct. No doubt similar attention to the mounting medium would, in many other cases, produce a like improvement in the appearance of the object. I will only adduce another example—two mountings of shell; that in gelatine shows the laminations more distinctly than that in balsam.

Various other matters, more or less important and interesting to the microscopist and optician, might be treated of, in connection with this part of my subject, but contenting myself with what I have said, I will revert to some of the other questions raised at the beginning of my paper.

Are white organic materials ever opaque?

Are all opaque substances black when in a fine state of division?

How far is blackness coincident with opacity and heterogeneousness or division?

How far is whiteness coincident with transparency and heterogeneousness or division?

Is anything opaque?

Is anything opaque? That is the question which ought to have preceded and superseded some, at least, of the others. We can only answer it inductively from the results of numerous observations. Glass is a transparent substance, approximately so, that is to say; for if we look through a plate of glass edgeways, we find it stops a great deal of light. It is not so transparent as pure water—and even water, as pure as it could be obtained by distillation, was proved by Professor Tyndall to have a blue-green colour when light was passed through fifteen or sixteen feet of it. A sheet of paper looked coloured seen through the water, but white seen through the same thickness of air. Is air, then, our only perfectly transparent medium? Even air is far from transmitting all the light which enters it. A comet is almost incalculably more transparent than the earth's atmosphere. The light of a star passing through hundreds of thousands of miles of a comet's atmosphere and nucleus loses less light than in passing through the thin stratum of air which covers the earth; yet even the comet is imperfectly transparent, and we do not know whether even the luminiferous ether itself allows the passage of light without some loss, but we know that glass is as much opaque compared with it as gold is when compared with glass; and from this we readily learn to believe that transparency and opacity are only comparative terms—that nothing transmits all the light, and nothing is entirely impervious to light; and this supposition is confirmed by experience, so far as I have been able to examine so-called opaque bodies in a way which gave reasonable prospect of satisfactory results. I will not trouble you with a detailed account of the experiments, but simply refer you to the table, and the objects to be seen under the microscopes:

LIGHT TRANSMITTED.

Through	Gold leaf	is Green.
„	„ tempered . . .	Brown.
„	„ chemical films .	Gray-violet.
„	„ „ powder.	Red, purple, or blue.
„	Silver leaf	Gray-violet.
„	„ chemical films .	Purple or brown.
„	Copper	Green.
„	Antimony	Gray.
„	Arsenic	Brown.
„	Platina	Gray.
„	Palladium	Gray.
„	Rhodium	Brown or blue.
„	Charcoal	Gray.
„	Iodine	Red-brown.

There are several objects on this list of which I have not got specimens; they will be found fully described, and their mode of preparation explained, in a paper by Faraday on "Gold in relation to Light," which was published in the 'Philosophical Magazine' a year or two since.

The tempered gold and silver leaf are remarkable for their great transparency, compared with that which has been beaten since it was annealed. May we suppose that the greater mobility in the molecules which characterises the annealed metal facilitates the luminous undulations? Or that there is an increased distance between the molecules which allows of the undulations passing more freely between them?

The chemical film of silver has two colours—inky purple at one part, and brown at another; probably others of the metals will be found by different observers to have colours different from those here attached to them.

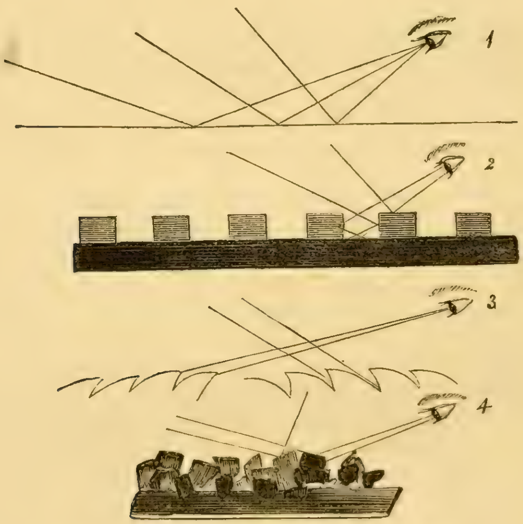
The antimony and arsenic were deposited from their combinations with hydrogen, as usually practised by the analyst. Of course this metallic arsenic must not be confounded with its white oxide, which is known by the same name. The specimens of charcoal are prepared from cork, pith, and common deal. Their tissues are not disintegrated by burning, and this affords us a ready means of obtaining amorphous carbon in thin films. In the deal charcoal the glandular deposits which characterise the vessels of coniferous trees may still be observed.

Returning to our questions, "What is the nature of proximate opacity?" The illustrations which I have given show that most bodies transmit a coloured light, the colour deepening as the thickness increases, until it is so dark that we call it opaque; but there is no reason why all colours may not be absorbed equally, and then we have gray light transmitted. This is the general result, as might be expected, with a heterogeneous body consisting of particles of various refracting powers, and each individually of little absorbing power. In most instances we find the opacity caused by both a considerable absorbing power and the action of heterogeneousness, as explained when treating of the bundle of plates.

It is more convenient to use words in their generally received meaning, therefore I will continue to call bodies opaque which, under ordinary circumstances, transmit no appreciable light; and, with this qualification, again ask, "Are all opaque bodies black when in a fine state of division?" The question was suggested by the fact that copper, deposited by electrotype, is of its usual colour if the current is of suitable intensity; it becomes granular and purple brown if the current is somewhat too powerful, and becomes pulverulent and almost black if the current is very intense. Iron, reduced by chemical means from its oxide, without undergoing fusion, is bright, dark gray, or almost black, according to the degree of comminution in which it is obtained. Platinum obeys the same rule. Coke is a shining gray where the surface is smooth; but when finely powdered, is black. So we might multiply instances; but there are exceptions, and they prove that though it may be a rule it is not a law. I will only adduce one example, that is, gold. Faraday has shown that it is a ruby red, a fine blue, purple, brown, &c., under different circumstances, but he did not obtain it black.

The other two questions, regarding the blackness or whiteness of substances in a fine state of division, and how far that is dependent upon their degree of opacity or transparency, may be shortly dismissed, for we have already considered the action of comminution on bodies of considerable transparency, and we have concluded that all substances are in some degree transparent. We have only now to repeat that reduction to a powder produces subjacent surfaces which reflect some of the light which passes through the first surface; the greater the degree of comminution, the more light is reflected from the subjacent substances. But reducing a substance to powder, by converting its surfaces into numberless facets, inclined at all conceivable angles to the general plane of reflection, diminishes the amount of light *availably* reflected from the *primary* surfaces, which will be more clear by considering it with the diagram before us.

In the diagram we have four eyes looking at different kinds of surfaces:—No. 1 will receive a certain amount of



light reflected from the plane surface. No. 2 will receive little more than half the quantity; it is supposed to be looking at a grooved surface in which the dentations are flat on the top, and separated by indentations of an equal width; half the light falls upon the tops of the ridges, and is reflected the same as from the plane; the other half falls into the grooves, and cannot reach the eye, except after many reflections and much loss. No. 3 looks at a serrated surface, in one portion of which A, the teeth, point from the eye; a considerable portion of light falls under the teeth, and is thus hidden from view; in the other case, at B, the eye sees principally the under or shady side of the teeth. The fourth eye is represented as looking at a powder, which, from its irregular nature, may be supposed to combine those various actions and many others tending more or less to detract from the amount of light entering the eye by direct reflection; there may be just as much reflected, but part being reflected from one particle to another, is more or less lost to sight. But if the particles of this powder are transparent, a portion of light is transmitted through several particles, one after another, and from the surface of each of these a portion is reflected, adding to the general luminosity. Probably the great reflecting power of white powders is partly due to some of the particles receiving the incident light at such an angle that the transmitted portion undergoes total reflection from their under side. I shall have occasion to notice total reflection again presently, and in the mean time I may remark that we should expect, from what I have been just pointing out, that a finely laminated material, such as this specimen of mica, would have the greatest possible reflecting power. I shall draw attention to this laminated mica again in speaking of lustre, and you will have the opportunity of observing that it really is a very powerful reflector.

Reverting to the powder, we may say that, with a certain *degree of fineness*, the quantity of light reflected from the subjacent surfaces depends upon the absorbing power—the more absorbing power, the less light.

Thus we conclude that bodies become lighter coloured by powdering, if the absorbing power is so small that the reflection from the subjacent surfaces more than compensates for the loss of reflection from the breaking up of the primary surface; and they become darker if the absorbing power is so great that the reflection from the subjacent surfaces does not compensate for the loss of reflection caused by the breaking up of the primary surface.

So far I have endeavoured to make our progress slow and sure, but I wish to lead you through a variety of other considerations which would render my paper too lengthy if treated in the same careful manner; I will, therefore, treat the remainder of the subject more briefly, more lightly, indulging in more speculation and less examination, and, I trust, it will be equally suggestive and less tedious than that which is past.

What is light? Undulation in luminiferous ether. What is heat? A motion in the molecules of matter. So, at least, they are commonly defined.

If heat is a motion in the molecules of matter, it cannot radiate except in the presence of matter. If radiation takes place with the velocity of light, we can only suppose it to be an undulation; if it takes place through inter-planetary space, we can only suppose it to be an undulation in luminiferous ether. What is heat? An undulation in luminiferous ether.

Light is only known to us through the nerves, and through the chemical action it exerts upon matter. A sensation and a chemical force, both of which we attribute to motion in the molecules of matter. Light a motion in the molecules of matter?

You perceive how readily the definition of one has been made to fit the other. How indefinite is our idea of any force in the abstract. We know the forces only through their effects upon matter; and though we wish to comprehend the cause which produces this effect, we must be very cautious in adopting any definition, for by confining our ideas within a false boundary, we may blind ourselves to the reception of truths which would otherwise flow upon us.

The time was—not long ago—when it was thought that light could be deprived of its heating power; when it was thought that light falling upon a black body was annihilated or absorbed. But the doctrine of the conservation of force has dispelled that of annihilation, and the theory of absorption is no more tenable. Expose some charcoal to sunshine for a thousand years, it goes on absorbing with undiminished power; but set fire to the charcoal, and will you behold that that thousand years of glorious sunshine is concentrated into a few moments? No! For it is not there to come out. The sunshine which has poured into it is no more there than if you had poured water into a sieve. It has been coming out as fast as it went in. It fell upon the charcoal as light, but it left it as heat, or some other invisible modification of force.

There is no such thing as annihilation, no such thing as absorption of light. Dark bodies only have the greater power of converting it into something else, a power probably the converse of that possessed by phosphorescent and fluorescent bodies, which convert some invisible rays into luminous ones.

The time was—not long ago—when light was believed to be reflected from the *surfaces* of bodies. And *now* it is only when we are on our guard that we bear in mind the thickness of matter required to reflect a ray. We know that in a soap-bubble we often see patches so thin that they do not reflect light, though they are still possessed of two surfaces. Faraday observed that some of the gold leaves he experimented with, when reduced very thin by chemical means, lost part of their reflecting power, though they continued to be free from any material injury to their surface or integrity; and the proof that some depth of matter, or, as Faraday expresses it, more than one thickness of atoms, is concerned in ordinary reflection. It is interesting to speculate upon the nature of the phenomena, and the motions of atoms which take place in reflection, and upon the influence of this necessary thickness of matter. Is the luminous wave only reflected in one phase of an undulation? If matter at some depth, however small, beneath the surface, continues to reflect light, at what depth does it cease to do so? Does it ever cease to do so? Or does the transmitted ray, as it speeds on its journey, always send back a beam in the opposite direction?

Different kinds of reflecting surfaces have different appearances; this is probably due in some measure to the effect produced upon the light by its passage into and out of that thickness of matter which is concerned in ordinary reflection.

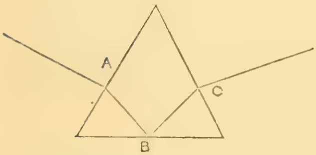
Of homogeneous matter we have opaque and transparent, the former giving metallic lustre, the latter vitreous. As a general rule, if not a universal, we find the more nearly a substance approaches the metals in opacity the more it resembles them in the nature of its lustre. Thus, sulphurets are in many cases very nearly opaque, and very like metals in the nature of their lustre. Carbon in its opaque form is a brilliant steel gray, while its transparent form has the vitreous lustre.

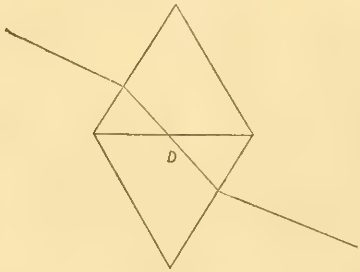
A micaceous or pearly lustre is the result of the superposition of a number of films of transparent material, the reflection from the first surface being added to by the reflections from the subjacent surfaces.

I use the word micaceous in preference to pearly, because the latter word so often is understood to mean iridescent, like mother-of-pearl; but the lustre now spoken of is free from prismatic colours. You will see it nicely illustrated in the specimen I exhibit, which is a little circular piece of mica, which, by heating, has been split into thin laminæ at the edges. These laminæ, when taken separately, are still transparent; but the great number of them, with air between each, scarcely admit the passage of any light, but reflect a great deal; while the middle of the disc, which contains the same amount of the same kind of matter, only wanting the air, transmits light freely and reflects but little.

A waxy lustre has the reflection from the primary surface supplemented by reflections from irregular particles beneath the surface; we have the phenomena also illustrated, and that on a larger scale, in polished marble and glazed earthenware, while the earthenware without a glazing reflects light without the appearance of lustre to the naked eye. I would willingly have enlarged upon the subject of lustre and its theories, but time is outstripping me, and I must hasten on.

The colour reflected from a substance is not always the same, and not always different from that transmitted. It is often, evidently, only with a conventional correctness that we state the colour of a material. We say gold-leaf is yellow, but we might also say that it is green—the transmitted light being different in this case from the reflected. But, further than this, we may say that gold is yellow by reflected light; but only as a convenient and conventional statement is it admissible, for we have seen that gold is brown, yellow, red, purple, and blue. It might be difficult to prove that these colours were any of them purely reflected. We have just seen reason to believe that reflection is always accompanied by transmission through a certain depth—that is, "through that thickness of matter concerned in ordinary reflection;" and we have just speculated upon the probability of transmission being always accompanied with some degree of reflection. I might instance a long list of colouring principles, each of which reflects a colour different from that which it transmits, but I will only draw your attention to my specimens of the familiar mauve and magenta, which reflect respectively green and yellow light. I cannot, however, leave the subject of reflection without questioning the correctness of another common statement. When light falls upon glass and is reflected, we say the *glass* reflects it; overlooking, it often happens, that the rare medium is, equally with the denser, concerned in the reflection which takes place. From a bright surface of glass in air there is considerable reflection; from the same surface when under water there is comparatively little, and if immersed in turpentine there is almost none. Is it not the surface of air, water, and turpentine, in contact with the glass, in these several instances, which reflected the light? If so, we may say that air reflects most light, water less, and turpentine least. If it is the glass which reflects in all three cases—the glass reflects most light, the glass reflects less light, and the glass reflects least light. Do not suppose that I wish to persuade you that the glass has no part in the reflection; I only wish to show, in a striking manner, that it is not the only agent—it is but a partner in the firm which does the business. A very good illustration of these two propositions is found in the total reflection which we observe most conveniently with a prism. The light entering by the surface A falls upon B, and is reflected through C. The brilliancy of the reflection is intense when air is in contact





with the surface B; but if you bring a second prism in *contact* with it, as at D, the reflection ceases, and the ray passes straight on. If it was the surface of the glass which reflected, why not have a greater reflection when you have two surfaces? But if it is the air which reflects, the displacing of the air by the second glass surface accounts for the reflection ceasing. If you place water there, you have a reflection very much less than from air, but very perceptible; with turpentine it is scarcely visible; and if mercury is substituted, the reflection, though greater than with these other materials, is yet decidedly inferior to that from air. No reflecting surface with which we are acquainted will bear any comparison with the brilliance of air, when total reflection from its surface is obtained in this way. Let me caution you not to misunderstand me on this point. I do not say that total reflection *cannot* be obtained from anything else but air; but that, in practice, it is always obtained from a surface of air in contact with glass or some other highly refracting substance, the glass as well as the air being requisite for its production.

In quitting the subject of reflection, I may remark that the brilliant surfaces of mercury, polished silver, &c., do not reflect so much light as we might suppose from their brightness; even common white paper reflects as much.

To illustrate this I have formed a little conical shade of white paper; under it is a convex reflector, formed by silvering the concave side of a watch-glass, and on the middle of the reflector is a little white-paper label. While covered by the shade the reflector appears of a dead-gray colour. It reflects abundance of light, but it wants the reflected *shadows* which are essential to the appearance of lustre, and while it is thus uniformly illuminated we easily perceive that the white paper reflects more light than the silver.

As the uniform light obtained by the use of these white-paper shades very much facilitates our estimate of the reflecting power of the objects under them, we will do well to compare the laminated mica and carbonate of magnesia with the white paper and silver. Under the other paper shade I have placed a small article of polished silver, just to draw your attention to the remarkable analogy between the appearance of a polished surface with this uniform illumination and the dead-white silver under ordinary circumstances.

Sir D. Brewster, and other writers on optics, give the length of a wave of white light, the number of undulations in an inch and the number in a second, calculating it as the *mean* of the number of undulations in the coloured rays, apparently forgetting that it is not the mean but the sum of the colours which forms white light—the mean being, according to Brewster's own table, yellow, with a tinge of green; various writers have, probably, copied from the same source without investing thought upon the subject, one indication of which is, that several say so many millions of millions, whereas it would be more natural to say so many billions. I will just give you Brewster's figures, and then pass on:

Length in parts of an inch.	No. in an inch.	No. in a second. Millions of millions.
White . . 0·0000225	44444	541
Yellow . . 0·0000227	44000	535
Yellow-green 0·0000219	45600	555

You observe the numbers given for white light are the same that would belong to a colour between yellow and yellow green. White light, we may conclude, is not a definite undulation, nor a definite mixture of undulations, but a variety of mixtures of undulations, in any of which mixtures the *average length of an undulation* is that given by Brewster and others, but the number in an inch or a second is incalculable and indefinite. The length of the undulations in a pure unmixed colour is probably definite, and we have no reason to object to the measure and number usually adopted; we shall, therefore, accept them for further argument.

The length of an undulation of violet light is seventeen millionths of an inch; the red undulation twenty-six millionths, or about one half longer; undulations longer or shorter than these not being visible. The colours observed in soap-bubbles and other thin films are produced by interference of the luminous waves. The colour produced depends upon the relation between the thickness of the film and the length of a wave of light. A film of air four millionths of an inch thick produces the same colour as a film of water three millionths, or of glass two and a half millionths of an inch thick. Therefore we conclude that the length of the light-wave varies with the medium. An undulation in air measuring four will measure only two and a half when it enters glass, and will again elongate to its former measure on its exit. From these premises we may deduce various interesting conclusions. Faraday found that gold-films were iridescent when they were only one tenth the thickness at which air ceases to be iridescent. May we then conclude that light, while passing through gold, consists of undulations only one tenth the length of those in air? Newton found that the thickness of films of a given colour was inversely proportionate to their indices of refraction. May we then conclude that gold has a refracting power in like proportion? If we say that luminous undulations, which in air measure twenty-two millionths of an inch, look yellow when they enter the eye, and in that organ measure one third less, in consequence of its refracting power, then we come to the singular conclusion that the blue sky is yellow, sunshine is red, and the rosy tints of evening are not luminous at all till they enter the eye. If the colour depends upon the length of the light-wave, and the length of the wave depends upon the refracting power of the medium through which it is passing, every beam of light changes colour; red it may be on its passing through the region of the stars, yellow or green it may be when it enters the air, blue or violet when it enters water, non-luminous as it passes through glass. But if light, which we perceive as violet while it exists in the aqueous humour of the eye, was red originally, what colour must that light be which we perceive as red? Its undulations in air must be too long to be luminous. This introduces us to the solemn thought that all this vast universe is dark! Light exists only in the eye. It is only a sensation, a perception of that which in nature exists as a force capable of producing a sensation. We would feel grieved at the thought of light and sound having no tangible existence independent of ourselves were it not for the glorious hope that all nature is full of forces equally grand, forces which we have not the power of perceiving, but which, with a higher development of our organism, may be sweet as music and genial as sunshine.

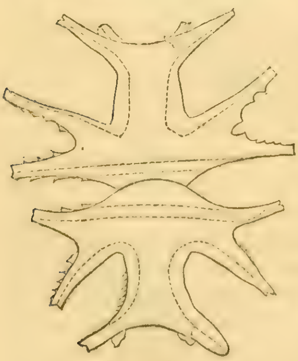
[In acceding to the request of the Newcastle Microscopical Society, that I would allow the preceding paper to be published, I think it but justice to myself, as well as to my readers, to state that it was written with the expectation of its being heard only by personal acquaintances; and its object was not so much to establish any new facts, as to draw attention to, and stimulate thought upon, a few commonplace phenomena and observations.

The former circumstance must be my apology for the colloquial style in which it is written; and the latter circumstance will, I hope, excuse the free use I make of speculation and queries. It was not necessary for my purpose that speculations should be well considered, so long as they were suggestive of interesting considerations.]

11, Grey Street, Newcastle.

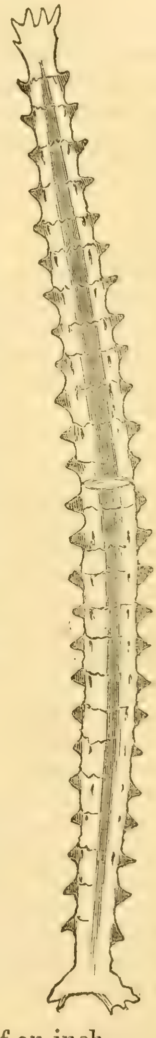
Notes on Indian Desmideæ. By Julian Hobson, Bombay Staff Corps, Mahabuleshwar.

I forward for publication two drawings of a *Micrasterias* and of a species of *Docidium*, together with a description of the latter. They are, I think, new species. The *Micrasterias* appears to be something allied to *M. Baileyi*, Ralfs (pl. xxv, 'Suppl.'), but that form is not in the least serrated. The *Docidium*, in some degree, resembles the one figured in the same plate, but the teeth in the form I propose calling *D. pristidæ* are very acute, and the terminal processes differ greatly. These two species are very common here, but nowhere else in the Bombay Presidency have I come across them. I have



× 350 diam.

met with upwards of half of the Desmideæ described by Ralfs up here. It may be that the climate is so much more like that of England than it is down on the plains. Many English ferns are met with here that are never found in the plains, and the same may also be said of the mosses.



Desmideæ.

1. *Docidium*, Bréb.

1. *D. pristidæ*, Hobs.

Frond slender, constricted at the middle; suture strongly marked, but not projecting on the sides; segments about nine times longer than broad, each with about twelve whorls of sharp, tooth-like projections, much resembling the saw-shaped weapon of the saw-fish.* Each tooth on the segments is visible, in their empty state, under its own focus. Terminal processes of very peculiar form.

Hab. In the streams running through the Chinamen's Gardens, near the lake at Mahabuleshwar; very common.

This species can hardly be identical with Professor Bailey's *D. verticillatum*, inasmuch as the teeth are sharp, and not obtuse, as in that species; nor are the terminal processes alike, which in the present species differ from those of any other species of *Docidium* with which I am acquainted.

2. *Micrasterias*, Ag.

1. *M. Mahabuleshwarensis*, Hobs.

Frond oblong, rather longer than broad, slightly constricted in the middle. The surface of the frond is covered with small granules, distinctly visible, bordering the whole of the sinuses. Segments trilobed; lobes bipartite, the end ones considerably exserted, having a broad but shallow notch, concave; sinuses serrated.

Length of frond	. . . . . . $\frac{1}{200}$th	of an inch.
Breadth ,,	. . . . . . $\frac{1}{240}$th	,,

* Whence the specific name.

Hab. In the streams running through the Chinamen's Garden, near the lake at Mahabuleshwar, about 5000 feet above the sea-level.

In this form each angle of the end lobe *appears* to be bifid; but as the longer ends come into focus before the shorter ones, I am of opinion that the shorter ones are the ends of the opposite side, which only slightly come into view, and give the bifid appearance; but with a Wenham's binocular this would easily be proved. The ends are narrow, and minutely toothed.

May 12th, 1863.

On Peculiar Appearances *exhibited by* Blood-corpuscles *under the influence of* Solutions *of* Magenta *and* Tannin. By William Roberts, M.D., Physician to the Manchester Royal Infirmary. Communicated to the Royal Society February 18, 1863.

('Proc. Roy. Soc.,' vol. xii, p. 481.)

The object of the following paper is to give an account of certain observations which seem to indicate that the cell-wall of the vertebrate blood-disc does not possess the simplicity of structure usually attributed to it.

It is well known that the blood-corpuscles, when floating in their own serum, or after having been treated with acetic acid or water, appear to be furnished with perfectly plain envelopes, composed of a simple homogeneous membrane, without distinction of parts. But, as will appear from the observations here to be related, when the blood is treated with a solution of magenta (nitrate of rosanilin) or with a dilute solution of tannin, the corpuscles present changes which seem irreconcileable with such a supposition.

Attention is first asked to the effects of magenta. When a speck of human blood was placed on a glass slide and mixed with a drop of a watery solution of magenta,* the following changes were observed. The blood-discs speedily lost their natural opacity and yellow colour; they became perfectly transparent, and assumed a faint-rose colour; they also expanded sensibly, and lost their biconcave figure. In

* The solution I found to answer best in these experiments was a nearly saturated solution of nitrate of rosanilin, made by boiling the salt in water, and filtering after it had stood twenty-four hours, then diluting slightly with water to prevent precipitation.

addition, a dark-red speck made its appearance on some portion of their periphery. The pale corpuscles took the colour much more strongly than the red; and their nuclei were displayed with great clearness, dyed of a magnificent carbuncle-red. Many of the nuclei were seen in the process of division, more or less advanced; and in some cells the partition had resulted in the production of two, three, or even four distinct secondary nuclei.

These appearances were first observed in freshly drawn blood from the finger. Subsequently blood from the horse, pig, ox, sheep, deer, camel, cat, rabbit, and kangaroo, was examined in like manner. The effect on the red corpuscles (to which all the observations hereinafter recorded are exclusively confined) was, in each instance, the same as in human blood.

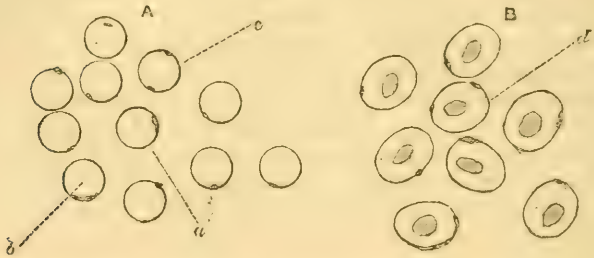
The nucleated blood-discs of the oviparous classes, when treated similarly, yielded analogous results. The coloured contents were forthwith discharged; the central nucleus came fully into view, and assumed a deep-red colour; the corpuscles expanded, they lost something of their oval form, and approached nearly, or sometimes quite, to a circular outline. Lastly, there appeared on the periphery a dark-red macula, of a character and position resembling that seen on the mammalian blood-disc. Such a macula was detected in the fowl, in the frog, and in the dace and minnow.

Owing, however, to the large quantity of molecular matter floating in the serum, and which was coloured by the magenta, difficulties were found in preparing specimens which carried conviction that the macula in question was not an adhering granule. It was also found that it required a nice adjustment of the relative quantities of the solution and of the blood to bring it out. It was only when the right proportions were hit, and especially when the discs were made to roll over in the field of the microscope, that the existence of a coloured particle organically connected with the cell-wall could be satisfactorily made out. The best specimens were prepared from human blood drawn in the fasting condition, and from the blood of a kitten two days old.

From well-prepared specimens of human blood the following particulars were gathered (see fig. 1):—Nearly every disc possessed the parietal macula; it could be distinctly recognised in nine tenths of them, and in several of those in which it was not at first visible it came into view as the corpuscles revolved in the field.

The macula was clearly situated in the cell-wall, and not in the interior of the corpuscle. Usually it appeared as if imbedded or set in the rim of the disc, like the jewel in a diamond ring; but sometimes it occupied various positions

Fig. 1.



A. Human blood. B. Fowl's blood treated with magenta.

on the flat surfaces, and when so placed the spot was difficult or impossible to detect.

It commonly presented a thickly lenticular shape; sometimes it was square, and occasionally in appearance vesicular. (Fig. 1, A, *a*.) In some instances, and especially in long-kept specimens, the particle was seen to stand out on the outline of the disc like an excrescence. Still more rarely, instead of a spot, a thick red line ran round the circumference for a quarter or a third of its extent. (Fig. 1, A, *b*.)

As a rule, it was extremely minute, covering generally not more than a twentieth or thirtieth of the circumference; but there was a considerable variation in its magnitude and distinctness. Very rarely two specks could be seen; but the occurrence of adhering granules rendered the verification of this point extremely difficult.

This description applies, so far as the inquiry has yet been prosecuted, to the mammalian blood-disc generally, making allowances for differences in size. In the camel the macula occupied indifferently any part of the oval outline.

Among the oviparous classes, the blood of the fowl, frog, dace, and minnow, has been most fully examined (see fig. 1, B); but the blood of the sparrow, duck, goose, and turkey, was also searched, as well as that of the newt and carp.

In all of these a tinted particle appeared, more or less constantly, in the cell-wall, when the corpuscles were treated with magenta.* The presence of a central nucleus in these

* In order to bring out the best results, it was found requisite to modify the strength and quantity of the solution for the different kinds of blood,

classes caused the macula to be invisible more frequently than in mammalia, inasmuch as it suffered eclipse when situated over or under the central nucleus.

In the fowl, dace, and minnow, it was found easy to bring out the parietal macula; in the fish two spots were not unfrequently seen. The macula was situated indifferently on any part of the periphery, and sometimes it projected from the surface. When happily prepared, the specimens were even beautiful. The central nucleus was dyed of the finest red; and on the delicate outline of the cell-wall hung the red parietal macula, offering a not altogether fanciful resemblance to the astronomical figures representing the moon coursing in its orbit round the earth.

At this stage of the inquiry it was conceived that an improved demonstration might be obtained by fixing the dye with a mordant, and then subjecting the corpuscles to a lavatory process, so as to get rid of the floating granules which so much interfered with the view. For this purpose a solution of tannin (which is one of the mordants for magenta used in the arts) was employed, and some advantage was found therein. When a solution of tannin, of three grains to the ounce of water, was added to blood that had already been dyed with magenta, it was found that the parietal maculæ had their colour intensified, and that they became more conspicuous objects. The investigation was, however, not pushed any further in this direction, for it was found that tannin alone produced an even more remarkable effect than magenta. To this effect I now desire to draw particular attention.

When a solution of tannin, of the strength of three grains to the ounce, was applied to human blood, or to that of the horse, ox, sheep, pig, or cat, the blood immediately became turbid; and when a drop was placed under the microscope, the corpuscles were found greatly changed, as represented in fig. 2.

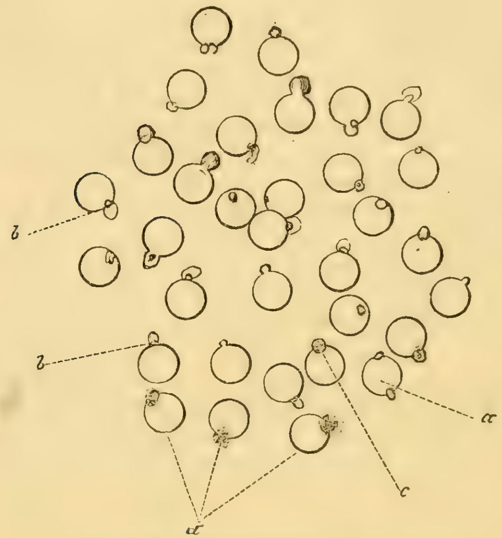
Each corpuscle appeared to have thrown out a bright, highly refractive bud or projection on its surface. The projections were usually about a fourth part of the size of the corpuscle on which they were fixed; but they varied considerably. Some were only minute bright specks in the cell-wall; others were half or even two thirds as large as the corpuscle itself. Very rarely (in mammalian blood) two such

This, doubtless, depended upon the varying densities of the liquor sanguinis and cell-contents in different animals.

projections were seen; and as rarely a corpuscle was devoid of any.

The projections were commonly round or dome-shaped, bordered with a deeply refractive outline. Frequently a

Fig. 2.



Human blood after the action of tannin.

a. Double pullulation.
b, b. Hooded modification.
c. Outline of the cell seen continuously through the pullulation.
d. Bursting of the pullulations independently of destruction of the cell.

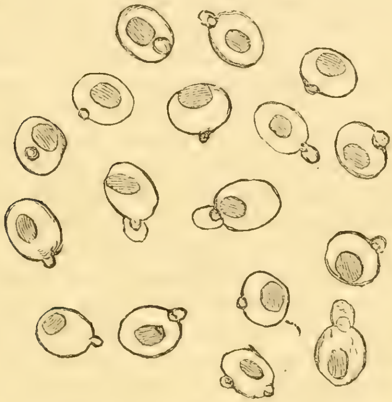
minute, apparently vesicular body could be seen within this outline, and then the projection presented a curiously hooded aspect. (Fig. 2, *b*, *b*.) In a urinary deposit from a lad twelve years of age, containing pus and blood, nearly every blood-disc presented the hooded appearance after the addition of tannin.

The blood of the fowl, turkey, duck, and goose, showed exactly analogous phenomena with the same reagent. (See fig. 3.)

The projection had sometimes the hooded character with a vesicular body within; sometimes the projection offered no such distinction of parts. It was situated indifferently on any part of the periphery. In all the birds examined a second projection was as rare as in mammalia.

Of fish, the dace, minnow, and carp, were examined. The tannin solution produced a similar effect to that seen in the fowl —with this difference, that a large number of corpuscles had

Fig. 3.



Blood of fowl after the action of tannin.

two projections instead of one. In the carp double and single projections occurred in about equal proportions; in the minnow double projections were all but universal. The second projection was situated sometimes at the opposite pole of the disc, sometimes in near proximity to its fellow, or at any point between. Very rarely a third projection was seen in the dace.

In the blood of the frog there was a strong tendency to the indefinite multiplication of the projections; two, three, four, and even five, would rise in succession on the surface of the disc. It appeared, too, not unfrequently as if the entire outer membrane of the cell was detached from the parts beneath, and raised into eight or ten unequal elevations, giving the outline of the disc an irregularly crenate appearance.*

The formation of these singular projections, or *pullulations*, on the blood-discs could be watched without difficulty by placing a drop of the tannin solution beneath the covering

* There is a certain adjustment of the proportions between the tannin solution and blood required to bring out the effects described in this paper; but the proper proportions are, practically, very easily found after a few trials for each kind of blood. In mammalian blood one drop of blood mixed in a conical glass with four or five of the solution generally answered perfectly. Any considerable excess of blood or solution above these proportions caused destruction of the corpuscles.

glass, and permitting a little blood to insinuate itself into the solution under the microscope. As the blood flowed in and mingled with the tannin, the corpuscles were observed gradually to enlarge, and then *suddenly*, without previous warning, to shoot out the projection. As a rule, it does not appear to grow afterwards. The phenomenon was finely seen in the defibrinated blood of the fowl after it had been allowed to sink through a column of syrup (sp. gr. 1025) in a test-tube. Fowl's blood washed in this way was mixed, in a little glass, with about five times its volume of the tannin solution, and a drop immediately put under the microscope. The discs first enlarge and become rounded, and the central nucleus comes into view. In thirty or forty seconds the pullulation begins; and each corpuscle, with instantaneous rapidity and without previous sign, throws out its bud. The disc itself suffers not the least disturbance during this act; it preserves its symmetry unchanged, as if it had no concern, beyond that of proximity, with the sudden apparition on its surface.

No visible rupture of the cell-wall took place. The circular outline of the latter could sometimes be distinctly followed through the projection (fig. 2, *c*); and as the altered corpuscles revolved in the field of the microscope, the projection appeared to be organically connected with it, but to form no part of its cavity. In the human blood-discs the application of acetic acid, soon after the tannin, caused, on two occasions, the pullulations gradually to subside, and finally to disappear, and then the disc resumed its original circular outline. I failed to produce this "redux" effect in the fowl; and did not always succeed with human blood, probably because the change produced by the tannin had gone too far.

The modification noted under the term "hooded" appearance depends, I believe, upon secondary conditions of concentration and quantity of the tannin solution in comparison to the blood. When the hooded condition has been watched in the act of occurrence, it was noticed that the outer hood was shot out *first*, and instantly after this the highly refractive vesicular body made its appearance within. The contents of the hood (excluding the vesicular body) appeared usually to refract the light like the body of the cell, or even less strongly; sometimes, however, more strongly.

The effect of tannin did not cease with the production of the elevations just described. At first the cells and their projections preserved their elasticity; but after a while (a few minutes, or several hours, according to the proportions used) the corpuscles and their projections become solid, and they could be cracked by pressure under the microscope like starch-granules. More slowly the same destruction overtook the corpuscles spontaneously; and this significant fact was observed in the course of it:—sometimes the cell ruptured before the projection, the latter persisting as a bright granule amid or near the débris; sometimes, on the other hand (in the horse), the projection broke up before the disc to which it was attached. In this latter case the hood (if there were any) broke up first into a scattered nebula of granular appearance, and then the nucleolus-like body within burst into three or four bright fragments. (Fig. 2, *d*.) This train of events seemed to remove all doubt as to the complete isolation of the projection from the cavity of the disc. Last of all, the disc itself began to crack; in a few days all my specimens were thus destroyed.

In addition to magenta and tannin, the following substances were tried, but they did not produce phenomena in the least analogous with the foregoing:—gallic acid, ferrocyanide of potassium, santonine, sulphate of magnesia, alcohol and water, solutions of carbolic acid, of atropine, morphia, iodine, sugar, gum, glycerine, and infusion of coffee.

A solution of picric acid produced the appearance of a parietal particle like that brought out by magenta, except that it was not coloured. An exactly similar appearance was on one occasion observed in blood-corpuscles in the urine of a patient with acute Bright's disease.

When magenta was applied after the process of pullulation had taken place, the projections were found to take the dye strongly, and especially the vesicular body within the hood. By this proceeding beautiful and remarkable objects for microscopical examination were obtained. In the fowl, dace, and minnow, the projection was tinted earlier than the central nucleus—probably from its more ready access to the pigment. The explanation of these appearances presents great difficulties, and in the present state of the inquiry can only be offered provisionally.

The effect of the magenta solution is not merely to tint, and so render visible a very minute body. In watching the effect of magenta, the first thing observed is that the natural yellowish colour of the disc is discharged, and that a faint rose tint is assumed in its stead. The discs at the same time lose their biconcave shape. The parietal macula is rather "brought out" than revealed, and the action of the solution is, to a very great extent, of a simply osmotic character.

The action of the tannin solution is likewise in the main of a similar nature, but modified in some very peculiar manner. Its first operation is to cause the corpuscle to enlarge by imbibition, and this goes on progressively until at length the cell is destroyed. If the solution be strong, this destruction supervenes at once. The tannin also unites with the cell-contents and coagulates them, imparting to the corpuscle, finally, a solid consistence. The conditions of the imbibition are disturbed by the previous application of magenta; for no pullulation, or at most only traces, occurs when the corpuscles are treated *first* with magenta and *then* with tannin.

The bearing of these observations on the current views respecting the structure of the vertebrate blood-disc is important. They seem to warrant the inferences drawn in the two following paragraphs:

1. The exact identity of the appearances produced in the blood-discs of the ovipara with those observed in the mammalian corpuscles lends strong support to the view that these corpuscles are homologous as wholes; and that the mammalian blood-disc is not the homologue of the nucleus of the coloured corpuscle of the ovipara, as was conceived by Mr. Wharton Jones.

2. The observations likewise lead to the belief that the envelope of the vertebrate blood-disc is a duplicate membrane; in other words, that within the outer covering there exists an interior vesicle, which encloses the coloured contents, and, in the ovipara, the nucleus.

Dr. Hensen,* of Kiel, had already, in 1861, convinced himself, from wholly different observations, that the blood-corpuscles of the frog possess such a structure. On this view the blood-corpuscle is anatomically analogous to a vegetable cell, and the inner vesicle corresponds to the primordial utricle.

The present observations indicate, by direct proof, a duplication at only one or, at most, two points in the blood-discs of mammals and birds. Nevertheless certain appearances, occasionally observed, favour the notion of a complete duplication. (Fig. 1, *b*.)

The admission of this hypothesis, however, scarcely removes the difficulties sufficiently to permit a tenable explanation to be offered of the appearances described in this paper. Yet, as it may prove suggestive to some other inquirer, I will not suppress what appears to me the explanation least open to objections. It might be conceived that the cells enlarged by imbibition, until at length the less dis-

* 'Zeitschrift für wissench. Zoologie,' Band xi, p. 263.

tensible inner membrane gave way, and permitted an extravasation of a portion of the cell-contents between it and the outer membrane, its own continuity being in the meanwhile instantaneously restored by cohesion of the ruptured borders.* In this way a microscopic drop of the cell-contents would be lodged between the outer and inner membrane, and completely severed from the general cell-cavity. The peculiar modification spoken of as the "hooded" appearance might be due to imbibition of fluid between this microscopic drop and the outer envelope.

The chief difficulties in the way of this explanation arise out of the differences of nature which appear to exist between the projection and the general cell-contents of which it is supposed to be a detached portion. The projection refracts light much more highly than the cell-contents; it also is deeply dyed by magenta, whereas the cell-contents are only very feebly so.

In conclusion, it may be added that important advantages may be expected from the use of magenta in histological researches. Its inert chemical character, its prodigious tinting power, and its solubility in water, eminently fit it for such a purpose. It will probably prove of especial use in bringing into sight objects which otherwise evade the visual organs from their absolute colourlessness and transparency, and from the equality of their refraction with the medium in which they exist.

NOTE *on the* COLOURING MATTER *of the* RED SEA.
By H. J. CARTER, F.R.S., &c.†

To those who have sought for all that has been published on the colouring matter of the Red Sea, it will be well known that the excellent memoirs on this subject by M. C. Montagne in 1844, and M. C. Dareste in 1855 (both in the 'Ann. des Sc. Nat.,' the former in sér. 3 ("Bot."), t. ii, p. 331, and the latter in sér. 4 ("Zool."), t. iii, p. 179), are the most elaborate.

* In the same manner as a soap-bubble, when bisected, instead of collapsing, forms, in virtue of the adhesiveness and fluidity of its envelope, two new and perfect bubbles. That the cell-wall of the blood-disc possesses some such endowment seems highly probable. I have on several occasions witnessed, after adding magenta, the total extrusion of the nucleus, both in the frog and in the newt, without the least collapse of the corpuscles.

† Extracted by permission from the 'Annals and Mag. Nat. Hist.,' March, 1863, vol. xi, p. 182.

But to Ehrenberg is due the merit of having first described (in 1826) the nature of the organism from which this colouring matter is derived. He found it in the Bay of Tor itself, pronounced it to be an Oscillatoria, and called it *Trichodesmium erythræum*, which Montagne has advisedly changed to *T. Ehrenbergii*.

No one who has read Montagne's memoir, and seen his illustration together with the organism itself, can doubt that the chief source of the red colour of the Red Sea is owing to the presence of this little Oscillatoria. Nor can any one doubt, who has read M. Dareste's memoir, that this is not the only organism which colours the sea red in different parts of the world.

It was to confirm the observations of the latter, as well as to record the fact itself, that I wrote the paper in these 'Annals' for 1858 (vol. i, p. 258), entitled "On the Red Colouring Matter of the Sea on the Shores of the Island of Bombay," wherein it is shown that this colour depends on the presence of a *Peridinium* (*P. sanguineum*, Cart.) in innumerable quantities, in which the chlorophyll at first is green, then becomes yellow, and lastly red, when the latter, mixing with the oil-globules generated *pari passu* in the cell, gives rise together to greater opacity, and thus reflecting more strongly, makes the presence of the *Peridinia* more evident, and causes the sea in which they are contained rapidly and almost suddenly to become of a vermilion or minium-red colour; after which, the *Peridinium* falls to the bottom and thus disappears, as if this were the termination of a cycle in its existence.

It was not, however (although I had formerly spent many months on the coasts of Arabia), until returning to England in June, 1862, on board the Peninsular and Oriental Company's steamer 'Malta,' that I had an opportunity of seeing the colour of the Red Sea which is produced by *Trichodesmium Ehrenbergii*—a circumstance to which I should not have alluded had not Montagne appended to his memoir certain queries which, in part, I can answer, at the same time that, with much diffidence, I offer a few remarks on Montagne's generic characters of this organism, which are repeated by Kützing in his 'Species Algarum.'

Commencing, then, with a short account of my own experience of *Trichodesmium Ehrenbergii* in the Red Sea, I would observe that, on the 31st of May, 1862, when approaching Aden, we passed through large areas of a yellowish-brown, oily-looking scum on the surface of the sea, and that on the 2nd of June, when off the Arabian side of the first islands sighted in the lower part of the Red Sea after leaving Aden, it again appeared, and we frequently passed through large areas of it, sometimes continuously for many miles, until we arrived off Jubal or the last island in the upper part of the Red Sea, when, from a calm, we steamed into a strong northerly breeze, accompanied by heavy sea, and saw no more of it. Once only I saw a portion of brilliant red and one of intense green together in the midst of the yellow.

The odour which came from this scum was like that of putrid chlorophyll, well known to those who have had much to do with the filamentous Algæ, both marine and fresh-water, but more familiarly to those who have not had this experience by that which comes from water in which green vegetables have been boiled—and hence very disagreeable.

I drew up some of this scum in a bottle, and found it to be composed of little, short-cut bundles of filaments, like Oscillatoria; for I had only a Coddington lens with me for their observation; and on showing them to Mr. Latimer Clark, the well-known superintendent for laying down the telegraph-cable through the Red Sea, &c., to Kurrachee, who was on board, Mr. Clark said that he had observed the same phenomenon in the Sea of Oman, where he had examined the filaments of the little bundles with a microscope, and had found them to be "beaded," to use his expression, "with rounded extremities."

On arriving in England, I had no time for examining microscopically the specimens which I had obtained, and which had been preserved in an equal quantity of alcohol added to the sea-water in which they had been taken, till January (1863), when I found the little bundles, which were still just visible to the unassisted eye, and like so much fine "sawdust" (to which they have been aptly and commonly compared by previous observers, who have seen them without knowing what they really were), varying in point of measurement, although, on the average, perhaps about $\frac{1}{50}$ inch long by $\frac{1}{100}$ broad, containing about twenty-five to sixty filaments, each of which is about $\frac{1}{50}$ inch long by $\frac{1}{2400}$ broad, their cells, which, of course, are so many discs, being sometimes thinner, sometimes thicker, than the breadth of the filament, with rounded cells terminately at the extremities where entire, but square when the latter have been broken off from the filament. The bundles bore no evidence of an investing sheath, but of the filaments being held together by mucus secreted from them generally.

Further into this description I need not enter, except to state that the cell was a true Oscillatorial one, charged with a few granules suspended in its protoplasm, and that I saw nothing like sporidification.

The colour of the bundles to the unassisted eye was still faint yellowish; but the filaments, under the microscope, were faintly green.

Of the questions proposed by Montagne (*op. cit.*, p. 355), the second calls for more information on the size of the bundles. This has been supplied above, so far as my observation extends.

The third question calls for information respecting the presence of *Trichodesmium* in the Sea of Oman, &c., as bearing upon the origin of the name "Erythræan Sea," applied by Herodotus to *all* the seas washing the shores of Arabia.

I have already stated that I saw the scum in the Gulf of Aden, also that Mr. Latimer Clark had seen it in the Sea of Oman; and the following extract from the late Dr. Buist's observations on the "Luminous and Coloured Appearances in the Sea" ('Proceedings of the Bombay Geographical Society' for 1855, p. 120) will show that it exists in the upper part of the Indian Ocean. The account from which this is taken was communicated to Dr. Buist by Dr. Haines, as witnessed on board the "Maria Somes," in lat. 21° N. and long. 42° E., and it stands thus:

"In May, 1840, when one third across from Aden to Bombay, the aspect of the sea suddenly changed upon us, and at once seemed as if oil had been poured upon its surface. It was still as a mill-pond, and of a brownish, soapy hue. The water, on being examined, was full of little fibrils, like horsehair cut across, in lengths of the tenth of an inch or so. A wine-glassful of it contained hundreds of them. . . . . We sailed through them for about five hours; so that they probably extended over a surface of 500 miles."

The occurrence, then, of *Trichodesmium Ehrenbergii* in the Red Sea, the Gulf of Aden, the Indian Ocean, and the Sea of Oman, is so far substantiated; and as the yellow colour in all instances probably passes into red, we have, apparently, the explanation of the whole of these seas having been called by the Greeks "Erythræan." I have not, however, heard whether it has been seen in the Persian Gulf.

Further, we learn from M. Dareste's memoir (*op. cit.*, p. 208) that João de Castro, in July, 1841, when off Cape Fartak, which is about the middle of the south-east coast of Arabia, found the sea so red that it appeared as if it had been coloured with bullocks' blood.

In my own experience of the Sea of Oman and the whole shore-sea of the south-east coast of Arabia from Muscat to Aden, where, under its survey, I passed all the months of the years 1844-45, and of 1845-46, with the exception of those of the stormy monsoon, viz., June, July, August, and September, the presence of the scum above described never, to my knowledge, was once observed. I am, therefore, inclined to infer that it is chiefly confined to the sea some distance off shore. Yet Ehrenberg, in 1823, saw the Bay of Tor covered with it, even up to the sands.

Lastly, I would advert (but, as before stated, with much diffidence) to that part of the generic characters of *Trichodesmium Ehrenbergii* in which we find the expression *"prime rubro-sanguineæ, tandem virides,"* first used by Montagne (*l. c.*, p. 346), and then repeated by Kützing in his 'Species Algarum,' because the facts connected with the accounts given of those who have seen the scum formed by *Trichodesmium*, together with my own experience of Algæ generally, lead me to the opposite conclusion, viz., that *Trichodesmium* is at first green, and subsequently becomes red.

It is true that its chief colour in the Bay of Tor, when seen by Ehrenberg, was red; it was red, like "red sawdust," when seen by M. E. Dupont in the Red Sea (*ap.* Montagne, *l. c.*); but, on the other hand, what I saw in the Gulf of Aden and in the Red Sea, together with what Mr. Latimer Clark saw in the Sea of Oman, and Dr. Haines, as above stated, in the Indian Ocean, was nearly all of a yellow oily colour; and this is the appearance that I have heard generally assigned to it by those who have been in the habit of traversing the seas mentioned.

Next to the yellow colour, red is the most prevalent, and green least of all. Some of that seen by Ehrenberg was intensely green; this was the case also with the green portion that I saw with the red above noticed; while Ehrenberg saw other portions of a less green colour. So much for what has been stated respecting the colours under which *Trichodesmium* has appeared.

We come now to the usual course presented by other Algæ in arriving at a red colour. If we take the *Peridinium* which colours the sea red on the shores of the island of Bombay, we shall find, as above stated, that it is at first green, then yellowish, and lastly red. In the green stage, the contents of the cell are so thin and watery that they easily allow the light to traverse them, and thus the *Peridinium* passes unobserved; but as they become inspissated, oil-globules generated, and the chlorophyll changed first to yellow and lastly to red, these contents become more opaque; and thus the

Peridinium, by reflecting much more light than it did at first, comes rapidly into notice, and by its numbers gives a general red colour to that part of the sea in which it may be present. The same is frequently—indeed, commonly—the course with *Euglena* in fresh-water ponds. The little *Protococcus* which colours the salt red in the salt-pans of the Island of Bombay, is green in the active period of its existence, but becomes red, and settles down into the "still form" of the same colour; while the common green *Protococcus* of the fresh-water tanks loses its red spot in the still form, and gains it again in the active or reproducing period of its existence. So red *Euglenæ* often becomes green; but the usual course appears to be for the green to appear first.

The red colour also appears to herald the termination of some period in the existence of the species. Thus the *Peridinium* above mentioned, after becoming red, loses its cilia, assumes the still form, and sinks to the bottom. The same is the case with the *Protococcus* of the salt-pans of Bombay; but instead of adhering to the salt, it seeks out and settles upon the crystals of carbonate of lime that are among those of the salt. The chlorophyll changes from green to red also in some of the resting spores of the confervoid Algæ, as in *Sphæroplea** and in *Protococcus pluvialis*, where also in both it becomes green again on germination, which led Cohn to state that the green colour is connected with "vegetation" or the early part of the existence of the individual, and the red with "fructification" or the termination†. So that, altogether, the passage of the colour from green to red in the filament seems to be more likely than the opposite.

Thus, as the evidence regarding *Trochodesmium* in the seas above mentioned is more, if anything, in favour of its yellow than its red colour, and that it is also sometimes green, while, in the common course, where algæ present red and green colours in their respective cycles of existence, the latter appears first, and the *Peridinium* above mentioned passes from green to yellow and then to red, &c., it seems not unreasonable to infer that *Trichodesmium Ehrenbergii* does the same, and that, therefore, so much of Montagne's generic characters of *Trichodesmium Ehrenbergii* as relate to its colour (viz., that it is "at first red and at length green") should be reversed.

If it were desirable to adduce evidence of the faint green colour which *Trichodesmium* probably presents in the first stage of its existence, from the observation, too, of probably

* Cohn, 'Ann. des Sc. Nat.,' 4e sér., t. v, p. 187.

† Ray Soc. vol. for 1853, p. 519.

the same organism in other parts of the world, one might cite those of Péron, who likens it to "poussière grisâtre," and of Darwin, who compares it to "cut hay," &c. (*op. cit.*); but it seems better for this argument not to go beyond the seas washing the shores of Arabia.

To what the "intense green," under which this organism sometimes presents itself in the Red Sea, owes its production I am ignorant, unless it be indicative of sporidification, which, from what I think that I have seen in *Oscillatoria princeps*, seems to take place in this family, not from the conjugation of its cells, but from the division of their contents into zoospores. Much, therefore, remains to complete the history of this little plant; and this, unfortunately, can only be obtained by watching it long and narrowly in its proper habitat.

TRANSLATIONS.

On the Contractile Filaments *of the* Cynareæ (Thistle Tribe). By Dr. F. Cohn.

(From the 'Zeitsch. f. Wissensch. Zool.,' xii, p. 366.)

The following observations are contained in a letter in the above Periodical addressed to Professor Von Siebold.

After referring to the circumstance that he had already on a previous occasion noticed, in a communication to the same correspondent, the most important facts relating to the contractile filaments in plants belonging to the thistle tribe, Professor Cohn proceeds to remark that in the Cynareæ the five filaments are inserted into the tube of the corolla, and support at their extremities the anthers which, as in all the Compositæ, are conjoined into a complete tube.

At the time of flowering, this anther-tube is closed at the end, and envelopes the pistil which arises at the base of the corolla from the inferior ovary.

At this period the anther-tube rises about 4 mm. above the summit of the corolla. When touched, pollen-masses are extruded from its apex, and at the same time the tube exhibits a peculiar twisting movement.

After about five minutes the experiment can be repeated; the pollen is again forced out of the tube, and the twisting movement will be again witnessed.

Gradually, however, the pistil rises above the summit of the anther-tube, and in proportion as it does so the irritability diminishes, until at length, when the stigma projects 4—5 mm. beyond the anther-tube, that property ceases to be manifested at all.

But it is not till this time, when its lobes begin to divaricate, that the stigma becomes capable of impregnation.

In general, not more than twenty-four hours at most elapse from the beginning to the cessation of the irritability, and frequently the space of time during which it exists is still shorter.

In many Cynareæ, when the irritability is not manifested, this will be found to arise from the circumstance that the flowers have been examined at too late a period. As a rule, it may be said to be too late when the stigma is visible above the anther-tube.

As is well known, the cause of these phenomena resides wholly and solely in the filaments, which each time they are touched instantly contract, and after a while extend themselves to their original length. The expulsion of the pollen from the anther-tube depends upon the circumstance that the tube, as the filaments shorten, is drawn downwards on the pistil about 1—2 mm., and is afterwards pushed upwards again. The contractility of the filaments is shown in the most interesting manner in preparations in which nothing but the anther-tube is left, and in which the five filaments have been cut away from the corolla, and thus rendered free to move independently. Under these circumstances they exhibit the liveliest irritability whenever they are touched; retracting themselves, bending and twisting out, and again becoming extended, and then bending over on the opposite side, twining themselves together, &c., so that it is hardly possible to escape the impression that we are witnessing the movements of a Hydra, and not those of any part of a plant.

Professor Cohn has, on a former occasion,* pointed out the laws by which these motions are regulated, and the conclusions he then arrived at have since been confirmed by the further observations of Kabsch† and of Unger.‡

He has shown that the contractile filaments were energetically affected by the electric current; contracting *instantly* under a *feeble* current, but again extending themselves after a time, and then again manifesting irritability.

A powerful current *kills* the filaments instantly; the consequence of which is that the contractile filaments do not again extend themselves, but, on the contrary, continue to contract more and more, until at the end of about an hour they are not more than half their original length.

When killed by other means, as, for instance, by immersion in alcohol, glycerine, or water, a similar shortening of the filaments to less than half their original length is observed; it is clear, therefore, that this contraction cannot be due simply to a *shrinking*, from *desiccation*. It may also be

* In a paper in the 'Abhandl. d. Schlesischen Gesellschaft. f. Vaterl. Cultur,' 1861. (An abstract of this valuable paper, by Dr. Arlidge, will be found in the 'Annals of Nat. History' for March, 1863.)

† 'Botanisch. Zeitung,' 1861.

‡ Ibid., 1862.

remarked that after spontaneous or natural death the filaments contract to the utmost.

Although, eventually, the pistil may project about 5 mm. beyond the anther-tube, this arises in the smallest possible degree from the growth of the pistil itself, after the flower has burst. The true cause of the apparent elongation is the retraction of the anther-tube by the shortening of the filaments after their death, and in consequence of which the tube will at length be found $\frac{1}{2}$ to 1 mm. *below* the summit of the corolla, *above* which, a few hours before, it had pro-projected 3—4 mm.

Having a short time since obtained a new microscope by Hartneck, Professor Cohn determined to investigate the *anatomical changes* undergone by the contractile filaments in their contraction.

In order to examine the filaments in the elongated irritable condition, it is necessary, first of all, to remove the air with which certain passages in the internal tissue are partially filled, and owing to which the transparency of the tissue is much impaired.

The air may be removed by placing upon a filament surrounded with water, a covering-glass, upon which the objective is screwed down with moderate force, and so as to subject the filament to a slight compression. The object is then to be pushed for its entire length under the objective. By this means the whole of the air is, as it were, squeezed out, and its place supplied with the water or glycerine, as the case may be; and the internal tissue covering the epidermis readily brought in view.

Fig. *a*.

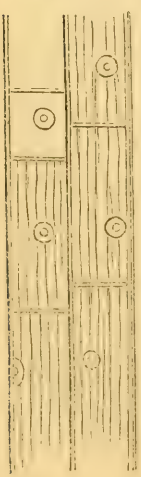
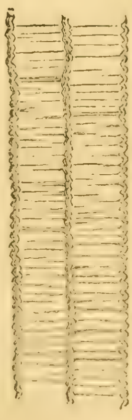


Fig. *b*.

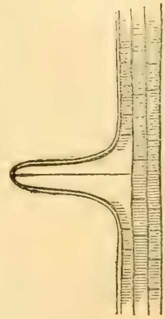


The tissue of the filament consists of a central vascular bundle, containing principally annular and closely wound spiral vessels, and surrounded by rows of elongated cylindrical cells, placed one above another, and separated by straight, transverse dissepiments. (Fig. *a*.)

Externally the filament is covered with an epidermis composed of similar cells, which, on the upper side, are thicker and convex, so that the filament appears, as it were, to be grooved.

(Fig. *d.*) The epidermis, again, is covered by a tolerably thick cuticle. Upon this cuticle rise peculiar, conical hairs, composed of two flat, contiguous cells, and whose gelatiniform, thickened membranes are also covered by the cuticle. (Fig. *c.*)

Fig. *c.*



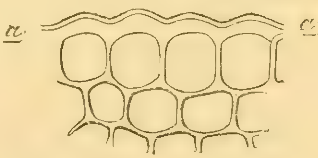
When the interior cells of an irritable filament in the state of *elongation* are placed under a sufficient magnifying power and accurately defined, or are exposed by a longitudinal incision, they appear longitudinally *striated,* as if furnished with longitudinal fibres. (Fig. *a.*)

But in the state of *contraction* their aspect is quite different, as is best seen in a filament which has already become shortened below the summit of the corolla. At this time the filaments have lost their vitality, as is proved by the contracted condition of the primordial utricle.

In this condition, if the air has been removed, all the cells present *close, transverse striæ,* as if the thin filament were composed solely of spiral vessels. (Fig. *b*). Those portions, consequently, of the filament in which more especially short cells exist exhibit the closest transverse striation, almost like that of transversely striped muscle.

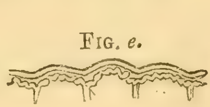
This appearance is due to the circumstance *that the cells in the act of shortening become very regularly and closely wrinkled.* The walls of the cells, consequently, appear to be very closely and finely plaited, as many as from ten to twenty transverse wrinkles occurring in the space of $\frac{1}{800}$ mm. The apparent fibres which, as above said, run sometimes perpendicularly, sometimes obliquely to the longitudinal axis, correspond exactly to these transverse wrinkles of the cell-wall.

Fig. *d.*



The corrugation is seen in all the cells, including those of the epidermis (figs. *d* and *e*), except that, as regards the innermost part, next to the air-passages, the cells often remain unwrinkled.

Fig. *e.*



The corrugation of the cells, consequent upon their shortening, may be observed to take place under the microscope, inasmuch as the water or glycerine entering the air-ducts kills the cells more or less rapidly; and as this takes place, the outline of the cells becomes undulated, whilst at the same time their walls are partially separated by a wider interval. After a little time the transverse striation of the cells is manifest throughout. The most extreme degree of shortening of a filament, and at the same time the closest transverse striation of its cells, is seen when it is brought in contact with a drop of sulphuric acid; by this reagent all the cells are rendered of a lemon-yellow colour, whilst the scattered pollen-grains, from the *coloration of their membrane*, become purple-violet. Concentrated sulphuric acid soon destroys the cell-wall, leaving only the cuticle, which is ultimately blackened. Potass also colours the cells yellow and corrugates them very deeply, whilst the membrane of the pollen-grains assumes a beautiful brown-red hue. Nitric acid, which gives the cells a pale-yellow colour (orange-red after addition of potass), contracts the cell-membrane, but it causes a remarkable distension of the cuticle, which is thus raised up in the form of an elevated pouch from the epidermis, and is detached even from the hairs.

If the filaments are crushed under strong pressure, the cells are unable to contract; but as soon as the covering-glass is raised, all the cells in an instant exhibit the transverse striation. The rugæ, however, owing to the far too rapid contraction, are very irregular, and whole masses of cells, under these circumstances, may be seen to become curved.

Although at present Professor Cohn has been unable to observe the action of *transitory irritation* upon the form of the cells, since the filaments which have been penetrated by water no longer react, he entertains no doubt that the *momentary* contractions caused by irritants depend, equally with the *permanent* shortening consequent upon death, upon the transverse corrugation of the cells.

It would seem, therefore, that the contractile cells of the Cynareæ correspond in their behaviour *essentially* with those of *unstriped muscle*, and we may *now* be said to be *acquainted with plants* in reality (so to speak) *furnished with muscles*.

The contractile cells are distinguished by the extreme delicacy of their wall, which is thinner than in any other tissue with which Professor Cohn is acquainted. It is only the extremities of the filaments upon which the anther is supported that are found to be composed of short, square, very thick cells, but these are evidently not contractile. Professor Cohn had on a previous occasion shown that the filaments become thickened in the same proportion that they diminish in length. A filament, for instance, that before it was irritated was $\frac{94}{1000}'''$ broad, became after irritation $\frac{115}{1000}'''$; another, from a width of $\frac{106}{1000}'''$ acquired one of $\frac{119}{1000}'''$; and a third, from $\frac{116}{1000}'''$ became $\frac{127}{1000}'''$.

In close connection with this is the circumstance that the cells before shortening are *longitudinally*, and after it *transversely*, striated.

In his former memoir, Professor Cohn had come to the conclusion that, in their elongated condition, the cells of the filaments were in a state of *active extension*, and that the shortening, either upon irritation or after death, depends upon a relaxation, in consequence of which the *elasticity* which had acted as an opponent to the expansion force, caused the contraction.

From this it would appear that the condition in the contractile filaments would be the opposite to that of the contractile animal tissue (muscle), inasmuch as in the latter the contracted condition is regarded as the active one and the elongated as the passive.

His later researches, he says, have served only to confirm the notion that the shortening of the filaments is of a passive nature, and due to elasticity, and he is, on this point, more than ever inclined to lay great weight upon the peculiar thickness of the cuticle, which even in the most completely shortened filaments exhibits no appearance of corrugation, and consequently must be in the highest degree elastic, so that it is able, after the death of the cells, to cause even a powerful contraction of the filaments by a transverse corrugation.

He is also convinced that at least *in the lowest animals*, which possess no muscles, but only a contractile parenchyma, a condition obtains similar to that observed in the contractile vegetable cells. In these animals also irritation causes a momentary and death an extreme and permanent contraction, consequent, in fact, upon the elasticity of their cuticle, whilst the extension and elongation is in them a vital, active process.

He refers, as a further instance of the same kind, to the stems of the Vorticellæ, which after death, as upon irritation, are rolled up, and again acting, extend themselves, and, again, to the processes of the *Amœba*, *Actinophrys*, *Difflugia*, *Arcella*, and the Rhizopoda in general, in which the elongation is manifestly an active process, whilst the same organs, upon being irritated, as after death, contract into a ball.

Experiments with contractile infusoria, which have been irritated by an electric current from an induction-apparatus, exhibit a perfect resemblance to the phenomena represented in the contractile vegetable tissues. *Trachelocera olor* suddenly contracts its neck and shortens itself; on a stronger current, it becomes flattened out, sarcode escapes and the entire creature becomes diffluent, whilst exhibiting the well-known wonderful contractions; the same thing takes place in *Paramecium aurelia*.

Lastly, *Hydra viridis* exhibits exactly similar conditions. The outstretching of its tentacles, the elongation of the body, is manifestly an active proceeding. When at rest and after death, it becomes shortened into an almost invisible particle. In like manner, a weak induction-current causes an instantaneous *contraction* of the body; under a continued current of the same strength, expansion gradually sets in again; a stronger current causes a renewed contraction; a very powerful shock induces contraction to the utmost; but *after this, expansion no longer takes place, but instead, a gradual dissolution of the body.*

The contractile phenomena in the parenchyma of plants and of the lower animals, consequently, so far as injury has as yet gone, follow the same laws.

Notes *on the* Anatomy *of* Sagitta.

Dr. H. A. Pagenstecher* has described what he regards as a new species of *Sagitta*, occurring at Cette. But as, unfortunately, he appears to have met with only a single specimen, his determination of its specific distinction cannot be regarded as definitive.

The specimen observed was furnished on one side with seven, and on the other with eight, large hooks. The smaller hooks were placed in two groups on either side, towards the middle of the under side of the upper lip. Each group consisted of five pointed spines, all directed backwards. The two anterior groups were situated nearer to each other than the posterior. A bundle of the minute, bristle-like hairs, which have been observed on the sides of the body in other *Sagittæ*, was in the present species noticed on each side, even of the head. The abdominal, anal, and caudal fins constituted a continuous expansion, surrounding the entire hinder part of the animal. The caudal portion of the *Sagitta*, though not more than 4 mm. long, was, nevertheless, filled

* 'Zeitsch. f. wiss. Zool.,' Bd. xii, p. 308, pl. xxix, fig. 8.

with spermatic elements; the peculiar spermatophores were already fully formed, and the ovaries were so much developed as to be readily forced by pressure into the head. It would seem, therefore, that the species is one of the smallest known. The principal peculiarity which especially induced Dr. Pagenstecher to direct attention to the form, consisted in the existence of a pair of special organs on the dorsal aspect of the head, one on either side. These organs were placed at the base of the upper lip, in front of the lateral bundles of setæ, externally and in front of the eyes. The organ itself consisted of a minute tube or sacculus, imbedded in the integument; the walls of the sacculus were coloured with opaque, brown, and inky pigment-molecules. It appears that these follicles opened on the sides of the head with a minute orifice, surrounded by a firm, strongly refracting border. Are these organs to be regarded as olfactory, or as analogous with the glandular follicles which are found in the cervical region in the Nematoda?

Leuckart and the author, in their common researches on the lower animals (of Heligoland), have shown that in *Sagitta germanica* the intestine is attached, not only by mesenteries, but also, as in the Nematoda, by a network of flattened bands, and, consequently, that there can be no question of the existence of a true perivisceral cavity.

In *Sagitta gallica* the most anterior border of the perivisceral space within which the intestine moves about freely during the movements of the hook-disc, and at which border these peculiar fixing bands are not seen, is distinguished by the presence of a complete transverse circlet of delicate, yellowish, oval cells, applied to each other by their lesser diameter. The intestine passes backwards through this ring, and by pressure the cæcal end of the ovaries can be forced in the opposite direction, towards the head. Externally to this is the sac formed by the obliquely and intricately interlaced muscular fibrils. From this arrangement it follows that the anterior portion of the intestine possesses great freedom of motion, in consequence of which the movements of the oral disc and pharynx are much facilitated. The organization of the border of the upper lip, the circle of large cells around the mouth, and many other peculiarities of structure belonging to the genus *Sagitta*, were also observed in this species. It is not impossible that Busch saw and figured the above-described organs in *Sagitta*, but he explained them as being retractile and protrusile tentacles, of which, however, Dr. Pagenstecher has been unable to perceive any vestige.

REVIEWS.

On an Undescribed Form of Amœba.

UNDER the above title, Dr. G. C. Wallich has lately published some very interesting observations on "Amœbæ, and allied forms of Rhizopoda," in the 'Annals of Natural History.'* In certain ponds on Hampstead Heath he obtained a curious form of *Amœba* in considerable quantities, and is of opinion that the peculiar characters presented by them are normal, although, perhaps, not permanent in their nature. "According to the descriptions of the commoner forms, such as *A. princeps*, *A. diffluens*, or *A. radiosa* (which he believes ultimately will be found to be mere transitory phases of one species), it appears that the sarcode-substance is uniformly differentiated into 'endosarc' and 'ectosarc'—in fact, neither the outer layer of sarcode nor the more viscid mass within is endowed with a more advanced degree of development at one point than at another." In the variety which Dr. Wallich describes this is not the case, one portion of the ectosarc in it exhibiting a structure differing permanently from the remainder, being densely studded with minute papillæ, "which," says Dr. Wallich, "in the quiescent state of the creature, are of nearly uniform aspect and size, and cause the surface upon which they occur to resemble the villous structure of mucous membrane in outward appearance. When the animal moves, these papillæ or villi vary in length, and now and then several coalesce, so as to form processes more nearly approaching the ordinary pseudopodial character, although still of minute proportions. The villous patch, which occupies probably from $\frac{1}{50}$th to $\frac{1}{70}$th of the entire superficies, appears frequently to be employed as a prehensile organ, the creature being enabled through its agency to secure for itself a continuous *point d'appui*, from which the rest of the body is pushed or flows onwards." True pseudopodia are not projected from this villous patch, but are freely thrown out from the remaining portion of ectosarc when

* 'Annals and Magazine of Natural History' for April, May, and June, 1863.

needful. The prehensile power of the papillæ is very great, so much so that when undue pressure has been exerted upon one of the Amœbæ it has been torn asunder, the portion provided with the villous area remaining attached to the glass slide on which it had been placed for observation. The great abundance of the Amœbæ in question in the ferruginous ponds of Hampstead, more than 95 per cent. of all the specimens being furnished with papillæ, has induced Dr. Wallich to consider this as a distinct species, which he proposes to call *Amœba villosa.* He, however, admits at the same time the probability of all the species of Amœbæ being local forms of one and the same type. The largest specimen which Dr. Wallich observed was $\frac{1}{50}$th of an inch in diameter. The villi, in their quiescent state, seem to be about $\frac{1}{1500}$ths of an inch in average length. In some instances the villous portion was placed on a long pedicle of ectosarc, so as to give it the appearance of a brush. In these specimens the villi seemed to have lost their prehensile power. In many cases an infundibuliform orifice was observed in the centre of the villous patch, from which numerous particles of matter were extruded, and also minute, perfectly formed Amœbæ, which Dr. Wallich regards as a proof of viviparous parturition among Amœbæ. The orifice was only temporary, but recurred frequently in the same position in various specimens and at various times. Dr. Wallich's observations on the nucleus and contractile vesicle are extremely interesting, and of great importance. He says, "The nucleus consists of a pale, gray-coloured, spherical mass of granules, towards the centre of which may occasionally be detected a minute, clear nucleolus. *It is contained within a hyaline and somewhat elongated vesicular cavity,* but never occupies the entire area of the latter." This vesicular cavity is separable from the rest of the Amœba, as a clear, membranous capsule, containing the granules of the nucleus. Dr. Carpenter and Mr. Carter have both spoken of the existence of a vesicular boundary to the nucleus, but they do not allude, Dr. Wallich believes, to the highly specialized membranous covering which is so remarkably manifest in *A. villosa,* and which seems to approach more nearly to the vesicle of the *Gregarinidæ.* Dr. Wallich assimilates it to the nucleus of *Plagiocantha, Thalassicola, Acanthometra,* and *Dictyocha.* The position of the nucleus in *A. villosa* is always, when at rest, in the vicinity of the villous patch. With regard to the contractile vesicle of Amœba, Dr. Wallich is of opinion, from careful observation, that it is not formed by any definite wall, as Carpenter and Carter have described it. In *A. villosa* the contractile vesicle appeared merely as an internal fissure in the sarcode-substance, and the existence of numerous vacuoles, which continually form and coalesce, or disappear, whilst under observation, seem to bear out this view of its nature. Dr. Wallich also confirms Mr. Carter's view, as opposed to that of Lachmann and others, that the contractile vesicle invariably discharges itself externally, the orifice being extemporised and of very minute proportion. On treatment with acetic acid and other reagents, no trace of a membranous envelopment to the sarcode-substance could be discovered, such as has been described by Auerbach in *A. bilimbosa;* but Dr. Wallich found that, by improper adjustment of the focus or want of proper illumination, the semblance of a double line, indicative of a true membrane, could be produced.

He gives his conclusions on the relations between the ectosarc and endosarc in the following words:—"From these facts it is obvious that the ectosarc and endosarc are not permanent portions of the Protean structure, but mutually convertible one into the other; and that it is an essential feature of sarcode that, whilst the outer layer for the time being becomes, *ipso facto,* instantaneously differentiated into ectosarc, the same layer reverts to the condition of endosarc under the circumstances just described"—alluding to the formation of food-orifices. In the granular contents of the protoplasma, Dr. Wallich found numerous rhombohedral crystals, about $\frac{1}{25000}$th of an inch in length, probably of lime. Such crystals he has also observed in *Euglypha, Arcella,* and *Acanthometra.* As is well known, Professor Huxley observed prismatic crystals in *Thalassicolla.* Certain bodies, which Dr. Wallich terms "nucleated corpuscles" (probably identical with the discoid ovules of Carter), were also found; their function is, perhaps, connected with reproduction. Other corpuscles, larger and nucleated, about the $\frac{1}{1800}$th an inch in diameter, were met with. These he has termed *sarcoblasts,* and considers them allied to the "yellow bodies" of Foraminifera, Polycystina, Thalassicollidæ, &c. In soundings from the Atlantic bed Dr. Wallich met with minute discoidal structures (previously detected by Professor Huxley), which he termed coccospheres, and believed to be a step in the reproductive process of Foraminifera. He now thinks it highly probable that the sarcoblasts first become coccospheres, or something equivalent, and are then developed into the perfect animal. This subject, however, he is about to work out. Dr. Wallich's observations are of the greatest importance. The discovery of this new form of Amœba, with the peculiarities of structure it presents, places the

Amœbæ in general in quite a new light, assimilating them more closely to other non-Rhizopodal genera, such as *Thalassicolla*, *Acanthometra*, &c., and placing them, in Dr. Wallich's opinion, at the head of the Rhizopoda.

On the Nervous System of the Nematoda.

The *nervous system* of the Nematoda forms the subject of an interesting paper by Dr. Anton Schneider,* whose previous contributions have contributed so largely to our knowledge of the anatomy of that class of worms. His first paper, "On the Lateral Lines and Vascular System of the Nematoda," appeared in 1858,† and has been followed by two others in 1860—"On the Muscles and Nerves of the Nematoda," ‡ and "Remarks on Mermis." § In his present communication he continues his observations on the nervous system, of which we proceed to give a brief abstract.

A nervous system was described, in 1816, by Otto, in *Strongylus gigas*, but the first important contribution on the subject was by Meissner, in 1853-55, who described what he regarded as a complete system of nerves in *Mermis albicans* and *nigrescens*. This was followed up by Wedl and Walter in a detailed account of the same system in another species. But the supposed nerves of these authors were shown by Dr. Schneider in the latter two papers above cited to belong to the muscular system; and his views have since been adopted by Leydig.||

Even with respect to the central nervous system, Meissner's views were entirely upset, what he regarded as such having proved to be the *œsophagus*. Dr. Schneider was unable also to confirm Walter's description of the central nervous system in *Oxyuris ornata*. The true constitution, therefore, of the nervous system in the *Nematoda* remained in considerable uncertainty. The only central organ that appeared likely to be such was a pale band lying on the œsophagus, first noticed by Lieberkuhn, Wedl, and himself.

Since that period, Dr. Schneider has kept the subject in constant view, and believes that he is now in a condition fully to describe both the central and peripheral nervous systems in the Nematoda. He attributes the success he has

* 'Archiv Anat.,' 1863, p. 1. † Ibid., 1858, p. 426.
‡ Ibid., 1860, p. 224. § Ibid., 1860, p. 243. || Ibid., 1861, p. 605.

met with to a mode of dissection peculiar to himself, and the want of which (though extremely simple) has hitherto prevented the successful prosecution of the research. The central nervous system constitutes a ring closely surrounding the œsophagus, but not attached to it. On the other hand, it is firmly connected by various processes with the walls of the body. This arrangement suggested the mode of dissection to be followed for its due display, and which is thus described:—Cut off a portion of the anterior end of an *Ascaris megalocephala*, for example, about half an inch long; then, with a fine and sharp pair of scissors, slit up the walls of the body together with the œsophagus; then cut off the lips and remove the œsophagus, and spread out the walls of the body, and the central nervous system will be seen lying uninjured on their inner surface. The essential part of the proceeding is the slitting up of the œsophagus as well as the walls of the body. The preparation is much improved by the boiling of it for a short time in dilute acetic acid, after which the cuticle can be readily removed and the specimen rendered transparent by glycerine. Specimens of *A. megalocephala* not fully grown are better fitted for examination than older ones, owing to their greater transparency. This dissection affords the readiest and easiest view of the entire nervous system, but in order to learn its minute structure numerous transverse sections are requisite. These sections must be very carefully made with the sharpest possible knife. To allow of their being properly made, the worm must be hardened, first in spirit, and afterwards in chromic acid.

Dr. Schneider's researches have been carried on chiefly in *Ascaris megalocephala* and *Oxyuris curvula*. In *A. megalocephala* the nerve-ring is placed about 2 mm. behind the oral orifice. From it six cords are given off in front; four of these (*nervi submediani*) arise nearly in the middle, between the border of one of the lateral intermuscular spaces and the middle line, though rather nearer the lateral space. The roots commence with a broad base, which gradually narrows into the slender cord. Two other nerves (*n. laterales*) lie in the middle of the lateral intermuscular spaces. These nerves are completely imbedded in the substance of the lateral space, and they may, with some pains and trouble, be at once dissected out, or may be seen more readily, but still distinctly, in simple transverse sections. Two strong nervous cords pass backwards; they arise on the ventral side of the ring, one on either side of the ventral line, towards which they tend in a sort of arch and are continued a short distance, but they cannot be traced beyond the arched anastomosis of the water vascular system which lies a short distance behind the nerve-ring. These are termed the *rami communicantes.*

In connection with these nerves are numerous ganglion-cells, which are found either in the course of the fibres or may be regarded as the points of origin of the fibres. The submedian nerves are furnished with but few of those bodies. The ganglion-cells are either *bipolar,* as are those occurring in the course of the fibres, or unipolar. The lateral nerves possess many more fibres than the submedian. Their fibres do not arise from the central ring alone. Numerous ganglion-cells of various sizes lie on all sides of the ring, and which are also unipolar and bipolar. Some might be termed multi-polar, were it possible to determine that all the processes arising from them were really nerve-fibres. These collections of ganglia are termed *ganglia lateralia.*

A large mass of the kind is found in the ventral line immediately behind the ring, and the cells composing it are, probably, most of them connected with the *rami communicantes.* In these ganglia (*ganglia mediana*) two halves may be distinguished, separated from each other by the tissue of the ventral line. On each side of the ventral line are placed six isolated ganglion-cells, two of which lie one behind the other, near the ventral line, and three others usually in the middle of the ventral space. These are unipolar. Their processes pass forward, and enter the middle ventral ganglion. The sixth cell is usually situated near the lateral intermuscular space. It is bipolar, and sends one process towards the median ganglion, and the other towards the lateral space. These cells are termed the *ganglia ventralia dispersa.*

In these latter may best be perceived the histological connection between the nerve-cells and fibres. Each cell presents a distinct nucleus and nucleolus. The nerve-fibres are of some width, and when divided exhibit an elliptical section. A distinct membrane may be perceived pretty clearly in the cells, but not in the fibres. The latter consist apparently of a homogeneous substance, resembling, when acted upon by chromic acid, coagulated albumen. The structure of the central ring is not so readily made out. In the fresh state it is so elastic as to contract into about half its circumference when separated from all its attachments. All that can be stated with certainty is, that the ring is enclosed in a tough and dense sheath, which also sends processes inwards into its substance. This sheath is finely striated; the striæ appearing to depend partly on fine rugæ, in part also upon distinct fibres. On the exterior it presents no indication of true nerve-fibres, which are best displayed when the ring has been boiled in dilute nitric acid, and torn asunder with needles. The fibres then exhibit the same structure and dimensions as the nervous trunks passing from the ring. Besides the fibres, however, the ring also contains bipolar cells, though in no great number.

The ring, as has been said, is closely connected with the walls of the body. The connection is effected chiefly by four bands, which appear to be, as it were, continued from the lateral and two median intermuscular areæ or spaces, and by them the ring is divided into four equal portions. But it is also closely connected with the muscular system by transverse prolongations of the muscle-cells, which constitute four bands, one of which is attached to each of the quarters of the ring, being continuous, as it were, with the sheath.

No further distribution of the nerves appears to have been clearly made out, although the author has made numerous and very industrious researches, which have shown him many interesting facts in the minute anatomy and arrangement, more especially of the muscular system, for which we must refer to the paper itself.

With respect to organs of sense, he states that in *Enoplus*, Duj., *Phanoglene*, Nordm., and *Enchilidium*, Ehr., eyes are indubitably present, although up to the present time no nerves have been traced to these organs.

Of other organs of sense, he points out certain structures which appear to be of the nature of tactile organs. These are tubular hollows in the integument, filled with a fine granular substance. On the exterior these follicles are either level with the surface or form small eminences of different kinds. These sort of papillæ are found in four different situations, and they may be classified into—1. Oral papillæ, varying in number from two to ten. 2. Cervical papillæ, always two in number, and lateral.* 3. Caudal papillæ, also always two in number, and lateral.† 4. Copulatory papillæ, situated in the caudal portion of the male, symmetrically, on each side of the ventral median line. No nerves, however, have as yet been traced to these organs, though Schneider thinks the submedian and lateral nerves go to the oral papillæ.

* The organs noticed by Dr. Pagenstecher in *Sagitta gallica* would seem to be of this kind. (Vid. *supra*, p. 193.)

† M. Bastian, in a paper read before the Linnean Society, and which will appear in the 'Linnean Transactions,' describes two organs of this kind (or of the next?) in the hinder part of the body in the young Guinea-worm.

NOTES AND CORRESPONDENCE.

A Simple Trough for Zoophytes, &c.—Perhaps the following cheap and easy method of constructing a small zoophyte trough may be useful to some of your readers, as I have found such articles extremely convenient in the examination of small Sertularian and other zoophytes.

Take an ordinary glass slide and cut it with a diamond into five pieces, A, B, C, D, E, as shown in fig. 1, or any

Fig. 1.

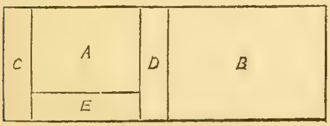
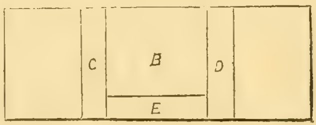


Fig. 2.



glazier will do it for a trifle if the lines are first drawn with a pen. The piece A being thrown aside, cement C, D, E, in their relative position on the middle of another slide, as shown in fig. 2, with marine glue. The piece B is to be cemented on the others, which it exactly covers, and the trough is complete. Being cut from one piece, C, D, and E, are certain to fit together. If more than one are being made, the covers, B, may be cut from thin slides, and thick ones may furnish the side pieces, C, D, E. Objects are, of course, introduced above, and are necessarily kept close to the front glass; this latter may be a square of thin glass for higher powers, as it can be easily replaced if broken. The contents are retained by capillary attraction, even when the body of the microscope is in an upright position; and the affair is as manageable on the stage as an ordinary object-slide.—George Guyon, Ventnor, Isle of Wight.

Feb. 17th, 1863.

The Photography of Magnified Objects by Polarized Light.—Crystals are generally looked upon as belonging almost exclusively to the polarizing class of microscopic objects. Their forms are, perhaps, the most beautiful in nature; but when we enter into their study, and penetrate somewhat deeply into the mysteries of crystallography, we meet with a very great drawback—the instability of certain crystals whose forms we find ourselves utterly unable to reproduce. Many of these endure for days, or even weeks, and then pass gradually away; whilst with others a second crystallization always takes place, which robs the first form of all its beauty, or destroys it altogether. In these cases, when the form illustrates some particular law, and it is desirable to preserve it, the *pencil* is usually employed. But some of these crystals exclude all chance of anything like a faithful drawing, by their intricacy of shape and the wearying labour that would be requisite to do them anything like justice. For these reasons I have been making use of photography by polarized light, and by this aid may be accomplished what could be done in no other way. In proof of this, I may mention that I have attempted by *ordinary* light a photographic impression of certain salts; but I found it impossible, as nothing, except a faint trace of the outline, was produced upon the plate, which is easily accounted for by the excessive tenuity (and consequent transparency) of the crystals. Again, by the use of common light the peculiar characters of certain substances are totally lost, as the cross of starch, &c.; but by the aid of the camera and polariscope all these may be permanently produced upon paper.

The power, also, of polarized light does not appear to be in any way inferior to that of ordinary light when used for photographic purposes; but I hope to be able to make some more conclusive experiments in this matter shortly, as it is absolutely necessary to employ a light whose power is constant. Another curious fact which I have observed as to the power of polarized light as applied to photographic purposes is this: when the object upon the slide appears most perfectly illuminated by the ray which has passed through the lower prism, we often find that the image in the camera is but *partially* distinct, and that we shall be forced to make a new adjustment of the mirror to procure an impression which will develop uniformly.

As to the position, &c., of the microscope, there is little to say, as it used in the ordinary manner of photographing magnified objects which has been so often described. The results, however, are better when the selenite plate is not employed, and the analysing prism is placed immediately over the object-glass. No. 1 eye-piece is, perhaps, the most preferable when the greatest distinctness is desired.

Herewith I send you four specimens of crystals photographed by polarized light.* The crystals of "tartrate of soda" is magnified forty diameters, and may be produced by neutralizing a strong solution of carbonate of soda with tartaric acid. A drop of this is then spread upon the slide, and the water evaporated by heat, when the salt will remain in a viscid state. The slide must then be laid in a dry place, free from dust, and in a short time will be covered with crystals, where the formless salt before lay. This will sometimes be found to be accomplished in a day, but at other times a week or two must elapse before the same result takes place, according to the warmth and dryness of the atmosphere. The crystal of sulphate of copper and magnesia is also magnified forty diameters, and was obtained by the method I havee lsewhere described. The crystal of santonin is also magnified forty diameters, but this salt requires a very different treatment to procure good crystals. A small portion is placed upon the centre of the glass slide, and this is then laid upon a metal plate, underneath which a spirit-lamp must be kept burning, in order that the temperature may not be lower than 350° Fahr., but if it is raised above 400° the crystals will turn brown. In a short time the santonin becomes fused, and with a hot needle should be thinly and evenly spread upon the surface of the slide, which should then be allowed to cool slowly. When the surface has become "fixed," a fine-pointed needle may be employed to pierce it here and there, when the crystals will spread from these centres and cover the plate. Castor oil must be used in mounting them, as balsam is apt to dissolve them when the temperature is raised even in a slight degree. The difficulty in preparing this salt is to know the precise moment at which to start the formation of the crystals, as those produced before and after this moment are devoid of that feathery delicacy which is their chief beauty. The crystals of tartar emetic are magnified fifty diameters, and were produced in the ordinary way. I have taken the trouble to describe the production of these crystals, because I am not aware that some of them have been before noticed as microscopic objects, and they are well worthy of a place in the cabinet.—THOMAS DAVIES.

* We had intended to give copies of the beautiful photographs sent by Mr. Davies, and which fully bear out his remarks, but find that the expense of this mode of illustration would be far too great, and are, therefore, obliged to forego what would otherwise have rendered his communication far more complete.—[EDS.]

On the Improvement of the Compound Microscope.—As I have bestowed much time, labour, and thought, in the endeavour to improve the construction of the compound microscope, I avail myself of the pages of your Journal to communicate the results to yourself and your numerous readers.

1st. It is imperative that the eye-piece be formed of two lenses of equal foci, and that they be placed a focal length apart.

2nd. These glasses must have as long a focus as can be used without interfering with manipulation.

3rd. The field-glass and objective must be placed at their combined focal distances apart.

4th. The cavity of the eye-piece may be filled with a fluid refractor, so as to represent a solid cylinder of glass cut from a sphere.

The glasses I am using have a focal length of ten inches, and the upper focus of the eye-glass is eight and a half inches in length, so that my tube measures something within thirty inches. The mist, darkness, and dirty *London fog*, met with so generally, are principally owing to the eye-lens having a short focal length; if, however, a glass be tried of greater focal length than the field-glass, the image will appear very light and clear, but with an unnatural glaze. Although a large amount of power is lost by equalising the lenses, this is fully made up by their long foci, necessitating increased distance from the objective. The length of the foci, of course, increases very materially the amount of light, which is gained further by placing the eye-piece and objective proportionally nearer together than is customary—the definition is at the same time improved. The introduction of a refractive medium between the upper lenses has the effect of magnifying the field and image about half a diameter, without shortening the foci of the instrument materially. With a simple $\frac{1}{3}$rd-inch lens for object-glass, I have the power of a $\frac{1}{5}$th-inch without the refracting medium, the light of a 1-inch; at least, an enlarged field definition, equalling, if not excelling, that of a simple microscope, and without perceptible change of colour—in fact, a *most faithful magnified view* of the object.

Instruments may be made of length suitable to the stature of the observer.—Fred. Curtis, Maryport.

16th June, 1863.

Infusoria in Moving Sand.—Mr. James Blake writes as follows from St. Francisco, California:—"I have enclosed some sand containing recent Infusoria, which, I have no doubt, will resume their movements on being moistened. They were collected on the moving sand-hills near this city, at a place a few yards from the ocean, and where there is not the least sign of vegetable life. My attention was attracted to them by seeing some concretions on the surface of the sand, which at the time was in motion from a strong wind. I found that these concretions consisted of agglutinated sand, the agglutinating substance being formed, as subsequent observation showed, by Infusoria. I could find no trace of organic matter in any of these concretions, which might have formed a nidus for the development of the Infusoria, and I have every reason to believe that these were developed in pure sand moistened with rain-water. I think the presence of rain-water was necessary for their development, as I had been over the same ground frequently before, during the summer season, and had not noticed the concretions, which I believe I must have done had they existed. The concretions were, in some instances, two or three inches long and an inch or two thick, and, when dry, they possessed considerable tenacity. I am unable to resolve the Infusoria into anything definite, with a $\frac{1}{4}$ of Powell and Lealand's.

[Our correspondent requests us to give some of the specimens to persons acquainted with Infusoria, which we shall be happy to do when they come to hand, which, we are sorry to say, they have not as yet done.]

Professor Eberth, of Würzburg, mentions the occurrence of a new parasite, differing, it is said, essentially from *Trichina spiralis*, which infests the voluntary muscles of the frog. It resides in the transversely striped fibrils, into and out of which it bores its way, moving about from one locality to another. This migration is proved by the existence in contiguous muscular fibres of cavities of a peculiar character. The description of the Entozoa is not given.—*Proceed. of Würzburg Phys.-Med. Society*, 1862.

PROCEEDINGS OF SOCIETIES.

Microscopical Society of London.

May 8th, 1863.

The annual soirée of the Society was held this evening in the great hall and other rooms at King's College, and though the requirements of the college obliged the Council to avail themselves of the accommodation during the Easter holidays, the attendance of members and their friends was quite equal to the usual average, and the exhibition of instruments and objects by the instrument makers as large and fully as interesting as on any former occasion. Absence from town, so customary at this season, prevented several of the well-known supporters of the Society from being present, and though the members contributed a larger number of instruments, they hardly made the same display as at some of the previous annual meetings of the Society.

The most striking feature as regards the instruments was the great increase and improved adaptation of the binocular arrangement of Mr. Wenham to all classes of microscopes, from the most elaborately finished and expensive stands of the first-class makers to the cheap but more generally useful and instructive, educational and student's instruments, for which the demand is so rapidly increasing. The stereoscopic effect, combined with really good definition and abundance of light, rendered the display of objects with low powers by this arrangement universally admired.

The exhibition of objects requiring very high powers is hardly so well adapted to please the visitor as the preceding, but the advance here made has been quite as great as in any other department, and the fine $\frac{1}{25}$th of Messrs. Powell and Lealand, and the $\frac{1}{20}$th of Messrs. Smith, Beck, and Beck, were exhibited, under all the disadvantages of a crowded room, in such a way as to show clearly to the microscopist what might be expected from their performance under the quiet and careful manipulation of the study. The large exhibition of instruments and improved thin stages of Mr. Ross also attracted a crowd of visitors to his table. It would be impossible, however, to enumerate all the various contrivances which have been invented to facilitate the growing taste for microscopical research of which examples were to be found on the tables of the Society, nor will our limits permit any detailed enumeration of the various and often highly interesting objects exhibited, though, as probably the greatest novelty, we may mention the exhibition, by Messrs. Horne and Thornthwaite, of the production of the new metal thallium by electric agency, which attracted much attention.

The number of microscopes exhibited was about 200, the greater part of which, as will be seen by the following list, were from the various instrument makers.

H. and W. Crouch	12	Pillischer	15
Gould	10	Powell and Lealand	6
S. Highley	6	Thomas Ross	24
Horne and Thornthwaite	10	Salmon	10
Howe	10	Smith, Beck, and Beck	12
Ladd	6	Steward	12
Murray and Heath	4	Topping	2
Newton	12	Weedon	2
Norman	3	The Society	4

The remainder were shown by members of the Society. The walls of the great hall were covered with a large collection of interesting diagrams, kindly lent by Dr. Carpenter, Dr. L. Beale, Mr. Mummery, and others, illustrative of the microscopic anatomy of the animal and vegetable kingdom; and Mr. F. Buckland kindly added to the attractions of the evening by the exhibition of his tanks, and by explaining the process of the artificial incubation of fish, the wonderful organization of the young fry being at the same time shown under the microscope.

May 13*th*, 1863.

Charles Brooke, Esq., President, in the Chair.

Dr. Pattison, Charles Cubitt, Esq., and J. L. Denman, Esq., were balloted for, and duly elected members of the Society.

The following papers were read:—"On some new Species of Diatomaceæ," by Dr. Greville; "On the Nerves of the Cornea, and their distribution in the Corneal Tissue in Man and Animals," by Dr. Ciaccio.

June 10*th*, 1863.

Charles Brooke, Esq., President, in the Chair.

F. Hager, Esq., F. Lycett, Esq., J. Garnham, Esq., Alfred Boot, Esq., Henry Crouch, Esq., and Charles Baker, Esq., were balloted for, and duly elected members of the Society.

A complete new microscope, with a series of nine objectives and apparatus, comprising all the latest improvements, was presented to the Society by Mr. Thomas Ross.

It was unanimously resolved—"That the most cordial thanks of the Society be presented to Mr. Ross, for his munificent gift, and that this resolution be suitably presented to him."

Mr. Deane gave a verbal account of the microscopical investigation of a palimpsest Greek MS. belonging to M. Simonides, and expressed his opinion that the same did not appear, from this examination, to be a forgery (as had been supposed), but that he had every reason to believe it to be a genuine document; in which opinion Mr. Wenham, who had assisted him in the examination, fully concurred.*

At the close of the regular business the MS. was exhibited to the meeting, and carefully examined by many of the members.

PRESENTATIONS TO THE MICROSCOPICAL SOCIETY, 1862-63.

October 8th, 1862.

	Presented by
Intellectual Observer, Nos. 6 to 9 . . .	The Editor.
The Canadian Journal, No. 40 . . .	Ditto.
Journal of Photography, nine numbers . .	Ditto.
Photographic Journal, Nos. 122 to 125 . .	Ditto.
The Annals and Magazine of Natural History, Nos. 55, 56, and 58	Purchased.

November 12th.

Dr. Carpenter's Introduction to the Study of the Foraminifera. Ray Society . . .	The Author.
On the Germination, Development, and Fructification of the Higher Cryptogamia, by Dr. W. Hofmeister. Translated by F. Currey, Esq., F.R.S. . .	F. Currey, Esq.
Dr. Carpenter on the Microscope, 3rd edition .	The Author.
The Popular Science Review, Nos. 4 and 5 . .	The Editor.
The Intellectual Observer, No. 10 . . .	Ditto.
The Journal of the Proceedings of the Linnean Society, Vol. VI, No. 24	The Society.
Transactions of the Tyneside Naturalists' Field Club, Vol. V, Part 3	Ditto.
Memorias da Academia Real das sciencias de Lisboa, 1854 to 1857	The Academy.
The Annals and Magazine of Natural History, Nos. 57 and 59	Purchased.
Seven Slides of Diatomaceæ . . .	W. Ward, Esq.

* We have since been informed that there is reason to believe that this opinion may prove erroneous.—[Eds.]

December 11th.

	Presented by
The Quarterly Journal of the Geological Society, Vol. XXIII, Part 4	The Society.
Intellectual Observer, No. 11	The Editor.
The Canadian Journal, No. 41	Ditto.
Notes on the Thysanura, by John Lubbock, Esq. F.R.S.	The Author.
Results of Meteorological Observations, Vol. I Smithsonian Report, 1860 Smithsonian Miscellaneous Collections, Vols. I, II, III, IV	Smithsonian Institute.
Journal of Photography, Nos. 178 and 179	The Editor.
Photographic Journal, No. 127	Ditto.
The Annals and Magazine of Natural History	Purchased.

January 14th, 1863.

The North Atlantic Sea Bed, comprising a Diary of the Voyage on board H.M.S. "Bulldog" in 1860, by G. C. Wallich, M.D., &c.	The Author.
Popular Science Review, No. 6	The Editor.
Intellectual Observer, No. 12	Ditto.
Sculptor's Journal, No. 1	Ditto.
Canadian Journal, No. 42	Ditto.
Journal of Photography, Nos. 180 and 181	Ditto.
Report of the Art Union of London, 1862	The Society.
Annals and Magazine of Natural History, No. 61	Purchased.
Twelve Slides—Deep-sea Soundings	J. Hilton, Esq.
One Slide of Diatom Earth and a Bottle of Vibrio-Wheat	C. Deane, Esq.

February 11th.

Journal of Photography, Nos. 182 and 183	The Editor.
Intellectual Observer, No. 13	Ditto.
Sculptor's Journal, No. 2	Ditto.
Annals and Magazine of Natural History, No. 62	Purchased.

March 11th.

Intellectual Observer, No. 14	The Editor.
Sculptor's Journal, No. 3	Ditto.
Journal of Photography, Nos. 184 and 185	Ditto.
Photographic Journal, No. 130	Ditto.
Journal of the Geological Society, No. 73	The Society.
Journal of the Linnean Society, No. 25	Ditto.
Annals and Magazine of Natural History, No. 63	Purchased.

May 12th.

Posthumous Works of Dr. Robert Hooke	F.C.S.Roper,Esq.
Beiträge zur Kenntniss mikroskopischer Organismen von G. Fresenius	Ditto.

	Presented by
Mikroskopische Studien aus dem Gebiete der menschlichen Morphologie von J. Gerlach . .	Ditto.
F. C. S. Roper, on the Genus *Licmophora* (paper) .	The Author.
Intellectual Observer, Nos. 15 and 16 . .	The Editor.
Popular Science Review, No. 7 . . .	Ditto.
Photographic Journal, No. 131 . . .	Ditto.
Journal of Photography, Nos. 186 to 189 . .	Ditto.
Transactions of the Linnean Society, Vol. XXIV, Part 1	The Society.
Annals and Magazine of Natural History, Nos. 64 and 65	Purchased.
Six Slides of Sulphate of Cadmium . .	G. Norman, Esq.
Two Slides—*Isthmia enervis*, *Triceratium arcticum* .	C. Baker, Esq.
Two Slides—*Licmophora flabellata*, *Lic. splendida* .	F.C.S. Roper, Esq.

June 10*th*.

Planta Cryptogamica da ordem dos cogumelos do genero *Aspergillus*, especie *Glaucus*, Dr. Carlos May Figueira	The Author.
Quarterly Journal of the Geological Society, No. 74 .	The Society.
Proceedings of the Linnean Society, No. 26 . .	Ditto.
Intellectual Observer, No 17 . . .	The Editor.
Photographic Journal, No. 133 . . .	Ditto.
Journal of Photography, Nos. 190 and 191 . .	Ditto.
Annals and Magazine of Natural History, No. 66 .	Purchased.
Nine Slides—Zoophytes from Australian Algæ (3), *Isthmia enervis* (2), *Licmophora flabellata*, *Meridion circulare*, *Rhabdonema arcuatum* (2) . .	J. Stainton, Esq.

W. G. Searson, *Curator*.

Literary and Philosophical Society, Manchester.

MICROSCOPICAL SECTION.

March 16*th*, 1863.

Mr. Joseph Sidebotham, Vice-President of the Section, in the Chair.

Mr. Watson presented specimens of *Jungermannia tomentella* and *asplenoides*, collected on Baguley Moor.

Mr. Sidebotham presented specimens of the following mosses, in fruit:—*Fissidens exilis*, *F. adiantoides*, *Grimmia pulvinata*, *Weissia controversa*, *Bryum atropurpureum*, &c., in a good state for microscopical examination.

Mr. J. G. Dale, F.C.S., presented a specimen of crystallized film of picrate of aniline; and in a note to the secretary explained his method of preparation from picric acid and aniline. The equivalent of picric acid is 229; that of aniline is 93; and when dissolved in strong alcohol in those proportions by weight, mixed and set aside, the picrate of aniline will crystallize in yellow needles. The film for the microscope is formed from a solution of these needles in absolute alcohol, a drop of which being spread over a clean, hot glass slide, the crystallized film is at once produced by the rapid evaporation of the alcohol, if the slide be at the proper degree of heat, which can only be found by repeated trials. If too hot, the salt will melt and become partially decomposed; if not hot enough, it will be crystallized in needles, or be deposited as an amorphous film. When properly crystallized, circular radiated discs will appear, with more or less regularity, showing with the polariscope very brilliant colours, and a black cross in the centre. The crystallized films may be mounted in *new soft* balsam; but a mixture of chloroform and balsam dissolves them immediately.

The Natural History Society presented for distribution amongst the members a number of beetles not required for the museum.

Mr. Nevill reported upon the fossil foraminiferous shells found in the Montreal deposit, presented by Mr. R. D. Darbishire at the last meeting. They were mostly in a fine state of preservation, and many were as perfect as recent shells. He found—

Polystomella,
Nonionina umbilicatula,
Polymorphina lactea,
Miliolina seminulum,
Entoselenia squamosa, var. *scalariformis*,
Ditto, of a peculiar form and rare,
Entoselenia marginata,
,, *globosa*, very fine,
Patalina corrugata,
Textularia,
Dentalina,
Lagena vulgaris.

The *Polystomella* and *Nonionina* were in great profusion; the other kinds were scarce; but Mr. Nevill was of opinion that remarkably fine specimens might be found of all the various kinds, if there were a larger quantity of material to operate upon. Mr. Nevill was indebted to the worthy President of the section, Professor Williamson, for verifying the names, and he presented to the section mounted and named slides for the cabinet. No Diatomaceæ were found amongst the material.

Dr. Alcock exhibited a young living salmon, about fourteen days old, attached to part of the ovum. Dr. Alcock particularly called attention to the form of the vertebral column, which, whilst young, is similar to that of the lower grade of cartilaginous fishes when fully grown; the skeleton of the salmon, however, becomes gradually changed, until at maturity it is that of the higher class of osseous fishes.

Dr. Alcock also exhibited a lingual riband of the *Patella athletica*, from Bray, in Ireland; he compared it with that of the common limpet, *Patella vulgata*, and pointed out the differences in the form of the teeth.

Dr. Roberts exhibited some mounted specimens of blood-corpuscles from an albuminous urine, which showed an appearance as if the contents of the cells had separated from the cell-wall, and become aggregated round the centre like a nucleus. When these corpuscles were treated with magenta, the central portion was either not coloured at all or only faintly so, whereas the circumferential portions became deeply tinted. By treating fresh blood with an excess of a solution of carbolic acid, this appearance could be produced at will. In the blood-corpuscles of the fowl a similar effect was produced by the carbolic-acid solution: the cell-contents appeared to detach themselves from the cell-wall and to collect round the nucleus. The appearances presented strongly suggested the idea that the cell-envelope of the blood-disc was a double membrane; that the inner separated under certain circumstances from the outer membrane and shrank in toward the centre. Dr. Hensen, of Kiel,* seems to have convinced himself that such is the case in the blood-disc of the frog, and he compares the inner membrane to the primordial utricle of the vegetable cell. Of the prolongations described by Dr. Hensen as stretching rapidly between the shrunk inner membrane and the outer one, Dr. Roberts saw nothing. If the said view of the structure of the blood-cells were substantiated, it would greatly facilitate the explanation of the appearances produced in these cells by magenta and tannin.

Mr. Charles O'Neill, F.C.S., exhibited a mounted fibre of Orleans cotton, torn by a gradually increasing weight suspended to its extremity. It had sustained a weight (gradually increased) of 162 grains for many minutes. Mr. O'Neill stated that there were 143 such fibres in ·01 grain of cotton, each fibre therefore weighing less than the ten thousandth part of a grain. The strongest fibres were capable of supporting more than two million times their own weight. He is engaged in making experiments upon the tensile strengths of various fibres by a special apparatus, but they are not yet completed.

Mr. Brothers exhibited a number of fresh-water insects, larva, &c.

Mr. Parry exhibited the transverse section of a fossil palm, from the Island of Antigua.

The following gentlemen were elected officers of the Society for the ensuing year:—President: Edward William Binney, F.R.S., F.G.S. Vice-Presidents: James Prescott Joule, LL.D., F.R.S., F.C.S., &c.; Robert Angus Smith, Ph.D., F.R.S., F.C.S.; Joseph Chesborough Dyer; Edward Schunck, Ph.D., F.R.S., F.C.S. Secretaries: Henry Enfield Roscoe, B.A., Ph.D., F.C.S.; Joseph Baxendell, F.R.A.S. Treasurer: Robert Worthington, F.R.A.S. Librarian, Charles Fredrik Ekman.

Of the Council: Rev. William Gaskell, M.A.; Frederick Crace Calvert, Ph.D., F.R.S., &c.; Peter Spence, F.C.S.; George Mosley; Alfred Fryer; George Venables Vernon, F.R.A.S.

* 'Siebold und Kölliker's Zeitschrift' for 1861, p. 263.

April 20th, 1863.

Professor WILLIAMSON, F.R.S., President of the Section, in the Chair.

Mr. Charles O'Neill, F.C.S., and Mr. John Shae Perring, M.Inst. C.E., were elected members of the section.

Mr. John Slagg, jun., and Mr. H. A. Hurst, were elected auditors of the treasurer's accounts.

Mr. Alfred Fryer presented for distribution amongst the members a number of impressions of an engraving of the *Acarus sacchari* found in raw grocery sugar, from Mauritius.

Mr. Brothers stated that he had made some observations upon the circulation in plants, and he found that a degree of heat which would cause free circulation in *Vallisneria* entirely destroyed it in *Chara vulgata*. Mr. Brothers also described the appearances presented by the cilia of *Melicerta ringens*, which he had the unusual opportunity of observing whilst the animal was outside its case in a dying state. As the motion of the cilia gradually became fitful and then ceased, it was apparent that the cilia of the inner row are much longer than those of the outer row, over which the former appear to bend and to crush off whatever may be adhering to them into the channel between the two rows. Thus are produced the wavy lines and apparent onward progression of the cilia, which render this, under suitable illumination, so brilliant and interesting a microscopical object.

Mr. Charles O'Neill, F.C.S., made a communication "Upon the Appearances of Cotton Fibre during Solution and Disintegration." These experiments referred to the application of Schweizer's solvent. Two strengths were used; the weaker contained oxide of copper, equal to 4·3 grs. metal per 1000 and 47 grs. dry ammonia; the stronger contained 15·4 grs. metal and 77 grs. dry ammonia per 1000. The latter is about the most concentrated solution which can be made. Referring to the researches of Payen, Fresny, Peligot, Schlossberger, and others, who have employed this solvent, the author said the only experimenter who seemed to have worked in the same direction with himself, and that apparently only to a small extent, was Dr. Cramer, whose paper he had only been able to see in a translation appended as a note to a memoir of M. Payen, in 'Comptes Rendus,' p. 319, vol. xlviii.

Mr. O'Neill considers that cotton exhibits, under the action of this solvent, (1) an external membrane distinct from the true cell-wall or cellulose matter; (2) spiral vessels situated either in or outside the external membrane; (3) the true cell-wall or cellulose; and (4) an inner medullary matter. The external membrane is insoluble in the solvent, and may be obtained in short, hollow cylinders by first acting upon the cotton with the dilute solvent, so as to gradually remove the cellulose, and then dissolve all soluble matters by the strong solvent. If the strong solution is first applied, the extraordinary dilation of the cellulose bursts the external membrane, and reduces it to such a state of tenuity that it is invisible. This membrane is very elastic, appears to be quite impermeable to the solvent, and when free from fissures protects the enclosed matter from its action. It is not seen in cotton which has been submitted to the action of alkaline acids and bleaching powder, being either chemically altered, or, what is most probable, entirely removed.

The spiral vessels are unmistakeably apparent, running round the fibre in more or less close spirals, sometimes single, sometimes double and parallel, and at other times double and in opposite directions, or again seemingly wound close and tight round the cylinder. They are well seen in the spherical swellings or beads, but are prominent at the points of strangulations of long ovals formed when the ends of the fibres are held tightly. They collect in a close mass, forming a ligature, and are frequently ruptured, the ends projecting from the side of the fibre.

The cellulose is enormously dilated by the weaker solvent, and expands the external membrane into beautiful beads, which are doubtless the result of the spiral vessels acting as ligatures at the points of strangulation; at the open end of a fibre it can be seen oozing out as a mucilaginous substance. The stronger solution bursts the beads, or dissolves all the cellulose into a homogeneous mass, amidst which the empty cuticular membrane and the spiral vessels remain nearly unacted upon.

The substance called medullary matter is seen occupying the axes of the fibres; it is nearly insoluble in the solvents. It may be well seen projecting from the open end of a fibre where the cellulose is exuding, and often remains *in situ* when the fibre has quite disappeared. It has many appearances of being a distinct body, but the author in some cases thought it might be only the thickened or modified inner cell-wall; in others it looked like a shrunk membrane, probably the dried-up primordial utricle. It is generally absent or indistinct in old cotton, or cotton which has been submitted to bleaching agents.

Mr. O'Neill intends to submit further details when his investigations are more advanced.

Mr. Hepworth stated that he had observed spiral markings in Sea Island cotton, not subjected to chemical action, and that he had calculated there would be about 50,000 spirals to an inch of fibre.

A Paper

On the Structure *of the* Valve *of the* Diatomaceæ.

By Charles Stodder.

From 'Proceed. Boston Soc. Nat. Hist.,' vol. ix, p. 2, 1862.

There are recorded a few observations which mention the existence of more than one plate of silex in the valve of some three or four species of diatoms. Mr. Shadbolt ('Trans. Mic. Soc.,' 1st series, vol. iii, p. 49) describes the valve of *Arachnodiscus Japonicus* as consisting of two layers. Mr. Ralfs ('Pritchard's Infusoria,' 4th ed., p. 839) says the valves of *Actinoptychus undulatus* "frequently consist of two dissimilar plates, one having the usual character, the other being triradiate and minutely punctate, and which has been described as a new species by Mr. Roper, who first observed it detached from the true valve. He and others have since found the plates *in situ*." Dr. F. W. Lewis ('Notes on New and Rarer Species of Diatomaceæ,' Phil., 1861, p. 6), describing *Navicula marginata*, speaks of "the outer siliceous plate." Schleiden ('Pritchard,' 4th ed., p. 41) speaks of "two leaves lying one over the other." Mr. Brightwell says of the lorica of *Triceratium*, that "the valves are resolvable into several distinct layers of silex, dividing like the thin layers of talc." (Pritchard, p. 49.) These are all the authorities I can find that intimate the existence of more than one plate of silex in the valve.

Ehrenberg describes several species of diatoms as "veiled"—a most happy term as expressive of the appearance of those species to which it is applied. Neither Ehrenberg nor any other microscopist has offered any explanation of the cause of this appearance. Among the species thus distinguished are the four species of *Heliopelta*, though the fact is not mentioned in any of the published descriptions, all of which are more or less imperfect.

Some time ago I found a broken specimen of *Heliopelta*, which exhibited clearly portions of the valve with the normal characters of the genus, and, extending beyond the broken edges, portions of another and inner plate of an entirely different structure. A few months since, Mr. J. S. Melvin gave me specimens of a diatom, as possibly a new species. On examination of these I found that he had obtained the inner plate of the valve of *Heliopelta Leuwenhoekii* entire and perfect. I have since found other specimens in my own collection. This plate under low or medium powers shows only exquisitely fine lines; but with a high power ($\frac{1}{12}$) it is resolved into minute spherical granules of silex, arranged in paralleled rows, radiating towards the margin of the disc, placed in contact with each other, and cemented together at their peripheries, the cement filling the interstices. There is a distinct line corresponding to the divisions of the compartments of the outer plate; a triangular blank at the junction of these lines with the margin, a conspicuous feature in the view of the perfect frustule; a star-shaped blank in the centre, the rays of the star being in number one half of that of the compartments of the disc. *Heliopelta* has the disc divided into six to twelve rays or compartments, one half of them having distinctly hexagonal areolæ, the alternate half having an entirely different kind of mark, which has never been perfectly described or figured. Dr. Carpenter's description is, perhaps, the best, but his figure is one of the most inaccurate. ('Carpenter on the Microscope,' Phil., p. 290.) The blank star of the inner plate is also a conspicuous feature of the perfect disc, and the rays of this star always coincide with the compartment last described. The inner plate also shows marks indicating the position of the marginal (improperly so-called) spines; and under a high power shows also faint impressions of the areolæ of the outer plate, which I consider proof that the two plates were in actual contact. It is this inner plate that gives the veiled appearance to this and other diatoms, and I take the "veil" in all cases as a visual proof of the existence of the inner plate. Dr. Carpenter says of *Heliopelta*, that a minute granular structure may be shown to exist over the whole of the valve—"that the circular areolation exists in a deeper layer of the siliceous lorica."

Now, I am certain that Dr. Carpenter was mistaken in this last remark, though, perhaps, not in what he saw. He had simply observed a valve with the inside toward the eye. I have repeatedly seen them in this position, and with the same effect. I have also found what I take to be the inner plate of an *Omphalopelta* entire; but the evidence of its connection with that genus is not quite complete.

A few weeks since I found a broken specimen of *Coscinodiscus;* the hexagonal areolæ were large and distinct, and extending beyond the broken edges, just as described in the *Heliopelta*, was another part of the disc, which was simply granular, with a milky aspect. This is the inner plate of the valve of that genus. Since that I have found numerous examples of the same kind, and am now satisfied that they are quite common, and that others as well as myself must have seen them often before, without being aware of their nature. Like the corresponding plate of *Heliopelta*, this is composed of spherical granules of silex, but instead of being in close contact, they are distant, and joined or cemented together by a thin plate of silex, the arrangement and place of the particles being governed by that of the hexagons of the outer plate, one granule being placed against each hexagon. By careful adjustment of the focus of the instrument, with a power proportioned to the size of the areolæ, the granules can be seen in the centre of the hexagons; care must, however, be taken not to confound an optical effect with the appearance of the granules; each areolæ is a minute lens, and so refracts the light as to give a bright or dark dot as the focus is changed, and the granules themselves contribute to this effect. Practice, however, will enable one to distinguish these effects.

The species *Eupodiscus*, *Argus*, and *Rogersi*, present strong evidence of the inner plates; so, also, do some specimens of *Isthmia nervosa*, of *Epithemia*, *Achnanthes*, and *Polymyxus coronalis.* I think I have seen indications of them in several other genera. In some of the *Pinnularia* and *Navicula* there are appearances which I can explain only on the supposition that the valve is composed of two plates, as suggested by Schleiden. Sufficient, I think, has been proved to warrant the generalisation that the valve of the Diatomaceæ consists of at least two plates of silex, the inner one of a structure more or less differing from that of the outer, giving that peculiar appearance to those species described as veiled,—partly the cause of the dots in the hexagonal areolæ of some species,—and often, probably, explaining the varying descriptions and figures of different writers.

There is a difference of opinion among diatomists as to the shape of the dots or marks of the very finely marked kinds, such as the whole of the genus *Pleurosigma*, Smith, *Gyrosigma*, Hassal, Mr. Wenham, by magnifying photographs of *P. angulatum* to 15,000 diameters, has proved, as I think, that the areolæ of that species (and undoubtedly of all the species with diagonal lines) have hexagonal areolæ, exactly like those of *Coscinodiscus*. Professor O. N. Rood, of Troy, by the same process, has obtained photographs of the same species (7000 diameters), which he thinks prove the areolæ to be circular. Professor Rood's photographs show some indications of the hexagonal form, and I believe the difference between his figures and Mr. Wenham's must be owing to some difference in the manipulation. The areolæ of the coarsely marked forms being unquestionably hexagons, it is probable, from analogy, that those of the finer forms are so also. Mr. Wenham, as quoted by Professor Rood, "states that he has ascertained by a $\frac{1}{50}$th that the markings of this object are due to spherical particles of quartz." ('Am. Jour. Science,' Nov., 1861, p. 336.) This observation, with the discovery of the inner plate of the *Coscinodiscus*, and its structure, makes the analogy of the structure of the two genera complete, and may be considered as proving the existence of the inner plate in this genus.

Another point in the structure of the valve has been a subject of much difference of opinion—some contend that the areolæ are elevations, others that they are depressions. Dr. J. W. Griffiths gives, in the 'Micrographical Dictionary,' his reasons for considering them to be depressions. I have reasons for thinking that neither party has the true explanation of the structure. My opinion is that the exterior of the shell is smooth or nearly so, and that the borders of the hexagons, or other shaped areolæ, and costæ of the costate forms, are internal projections from the outer plate, as on the under side of the leaf of the *Victoria Regia*, intended to give strength to the cell with the smallest quantity of material. This will explain the trace of the hexagons seen on the inner plate of *Heliopelta*, as only the projecting wall of the areolæ would come in contact with the inner plate. Dr. Griffiths reasoned that the areolæ were depressions because they were the thinnest parts of the shell; the facts are correct, but the inference may not be, as there is another explanation of the phenomena.

In company with Dr. C. T. Jackson, I have dissolved a shell of *Coscinodiscus* under the microscope, with caustic potash, and found that the area of the cellules was dissolved before the walls, and that therefore they are the thinnest parts, as Dr. Griffiths judged from the optical effect.

Hull Micro-Philosophical Society.

The fifth sessional course of papers delivered by the several members of this society terminated on March 20th last. These were mostly of an interesting character, and the meetings were generally well attended. An increasing interest in microscopical research is manifest, and several additional applications for membership have been made. Several new instruments have latterly been introduced from the manufactory of Mr. Cooke, optician, of Hull, of exquisite workmanship, compact design, and perfect stability. The society in its pecuniary resources may be said to flourish, and withal to present every fair prospect of utility and success.

An abridgment of some of the papers may be stated as under:

George Norman, Esq., the President of the society, in introducing the subject of diatomaceous deposits, stated his fears that in the short time allowed for his paper little more than a discursive glance could be given to the subject, and that, perhaps, on some future occasion he would bring the subject again before the members.

The occurrence of Diatomaceæ in a fossil state is, on the authority of Ehrenberg, constant in the chalk rocks. The President stated that, so far as his own experience went, no traces had been found in true chalk; perhaps, however, in the Paris beds the case might be different.

The possibility of the flint nodules in chalk being the amorphous state of former siliceous frustules was next touched upon. The most important deposits occur in the pliocene and plistocene formations immediately following the cretaceous rocks. The enormous deposits of Maryland, Virginia, and Algiers, were probably to be referred to this period. The fresh-water deposits of Finland, Bohemia, North America, Dolgelly, Toome Bridge, &c., were probably of a far more recent date; these were all, at some remote period, the beds of former lakes and morasses. The President alluded to the extensive deposit he had himself visited at Toome Bridge, in the county of Antrim. More recent deposits still are found underlaying peat beds, containing diatoms, with few exceptions, identical with forms now found living. The very ancient peat beds found about twenty-five feet beneath the alluvium of the district of Hull and neighbourhood contained very slight traces of Diatomaceæ. A sample taken from a deep excavation at Spring Head had furnished very sparingly *Pinnularia cardinalis*, a species which had hitherto never been found recent. The ancient peat deposit and sunken forest cropping out of the sands at Hornsea contained also *Pennularia cardinalis*, mixed with many recent forms. This great bed was probably the bed of a former mere like the existing Hornsea Mere.

The President proceeded to state that, in all probability, the site of the present Hornsea Mere would, at some future time, furnish a diatomaceous deposit more or less rich. The sea would in time wear away the narrow piece of land separating the mere from the ocean sand, and mud would be deposited over the entire area, and the mass of diatomaceous frustules, the accumulation of ages, would be consolidated into a white mass, such as we find in any ordinary deposit, the long rotting process having removed the brown endochrome. An instance was given of the gradual formation of such deposits before our eyes. Only the past summer the President had obtained a piece of tolerably white deposit from the bed of the Spring Ditch, which was in course of being filled up; it contained all the recent species which have been known to exist there by the previous examinations of microscopists. This once favorite locality is now destroyed through the extension of public works.

In conclusion, the President hastily glanced over the various uses these deposits were turned to, instancing such commercial products as tripoli, plate powder, floating bricks for powder magazines on board ship, &c.

The clays eaten by the natives of South America and in the interior of Africa were also, probably, diatomaceous deposits like the well-known Berg-Mehl of Lapland.

Mr. H. Prescott produced a paper, entitled "The History and Physiology of a grain of Barley," illustrating the germination of barley in its most rudimentary form, and then tracing its growth into a plant and the further development and structure of stem, root, flowering, spike, spikelets with floral appendages, sexual organs, pollen, starch, &c.

The peculiarities of growth of stem (straw) structure and the various appearances of the inflorescence during different stages of development were illustrated by numerous etchings.

On another occasion during the session, Mr. Prescott ("On the Structure of certain Seeds"), failing time and opportunity to give the meeting the benefit of any special studies that he might be competent to undertake, which were still incomplete, thought that a work bearing immediately on the subject, prepared for the use of Government by Drs. Hooker, Carpenter, Graham, Lindley, &c. (a copy of which he was fortunate enough to possess), might have some interest for the meeting. Sketches and letterpress were both valuable, as showing how master minds commanded and carried through the working out of a subject quite new to themselves. In this instance, as in the determination of genuine and adulterated coffee, the meeting would not fail to observe how well the microscopic characters of the substances had been preserved in drawings which bore the stamp of truth upon them. The elaborate researches of Dr. Graham and others on the gravities of the different substances in solution were equally admirable.

Mr. Hunter's paper, "On the Structure of Animal Hairs," was illustrated by numerous slides, including different coloured human hair, hairs from the several classes of animals, insects, &c., and hairs from different parts of the body of the same species. Much emphasis was laid upon the difficulty of identifying individual hairs, and also the want of a suitable medium for permanent mounting of specimens; the inefficiency of Canada balsam was shown by specimens otherwise mounted (fluids) exhibited in contrast, although balsam might answer best for dark ground and polariscope investigations.

The so-called whale hair was handed round the tables—a substance showing most of the microscopic properties of both hair and bone. The excellent felting properties of the hairs of the Carnivora and Rodentia was dwelt upon, and also the striking differences in those of the Ruminantia.

The adulterations practised by some workers in ornamental hair was illustrated by specimens mixed with hair from the alpaca and some species of goat.

Beautiful slides from the Ornithorhyncus and Gopher (from the banks of the Mississippi, Iowa) were compared; the only two kinds examined having the combined properties of wool and hair from the same root.

Mr. Ball, of Brigg, in Lincolnshire, read a very interesting paper "On the Anatomy of the Snail," which was illustrated by exquisite dissections and preparations of all the principal organs. The language of ordinary comment fails to give due expression to the Society's appreciation of this gentleman's labours and microscopic productions.

Mr. Stather effectively exhibited the powers of the binocular microscope.

A paper "On the Stings, Ovipositors, and the cutting parts of the Proboscides of Insects" was produced by Mr. Hanwell, showing the general resemblance of these parts, in some instances as to nearly appear identical. The nature of the true sting was shown, the incising apparatus attached to the head compared with it, and a classification made of the forms of the instruments used, from the simple lancet to the more complicated apparatus of the highly organized insects; the beautiful adaptation of means to ends, as exhibited in the various kinds of ovipositors, was dwelt upon. The paper was well illustrated by numerous slides prepared by this gentleman.

Dr. Kelbourne King delivered an article "On the Nervous Tissues," illustrated by slides of the nerve-cells, of considerable interest and beauty, and calculated to awaken the further attention of anatomists and physiologists to these very important structures. Preparations variously mounted in naphtha solution, glycerine and gelatine—the two latter both plain and coloured with carmine—were handed round, but, notwithstanding the beauty of carmine preparations, in these instances the naphtha solution appeared to afford a more minute structural detail.

Mr. Hendry exhibited the saccharo-polariscope, and the opposite order of colour phenomena of grape and cane sugars, with great effect; also delivered a paper, with illustrations, "On Spermatozoa," in the absence of Dr. A. M'Millan, otherwise engaged; and upon a third occasion introduced the subject of the connective tissues.

The session now terminated, embodying in its series of subjects matter amply adapted to call forth the active energies of its various members.

WM. HENDRY, *Hon. Sec.*

A PAPER

On the EMBRYOGENY *of* COMATULA ROSACEA (Linck). By Professor WYVILLE THOMSON, LL.D., F.R.S.E., M.R.I.A., F.G.S., &c.

(From 'Proceed. Roy. Soc.,' Feb. 5, 1863.)

AFTER briefly abstracting Dr. W. Busch's description of the early stages in the growth of the young of *Comatula*, the author details his own observations, carried on during the last four years, on the development and subsequent changes of the larva. After complete segmentation of the yolk, a more consistent nucleus appears within the mulberry mass still contained within the vitelline membrane. The external, more transparent, flocculent portion of the yolk liquefies and is absorbed into this nucleus, which gradually assumes the form of the embryo larva, a granular cylinder contracted at either end and girded with four transverse bands of cilia. This cylinder increases in size till it nearly fills the vitelline sac, gradually increasing in transparency, and ultimately consisting of delicately vacuolated sarcode, the external surface transparent and studded with pyriform oil-cells, the inner portion semifluid and slightly granular.

The vitelline membrane now gives way, and, usually shortly after the escape of the larva into the water, the third ciliated band from the anterior extremity arches forwards at one point; and in the space thus left between it and the fourth band, a large pyriform depression indicates the position of the larval mouth. At the same time a small, round aperture, merely separated from the posterior margin of the mouth by the last ciliated band, becomes connected with the mouth by a short, loop-like canal, passing under the band, and fulfils the function of an excreting orifice. A tuft of long cilia, which have a peculiarly undulatory motion, is developed at the posterior extremity of the body. The larva now increases rapidly in size, assuming somewhat the form of a kidney bean, the mouth answering in position to the *hilum*. It swims freely in the water, with a swinging, semirotatory motion, by means of its ciliated bands and posterior tuft of cilia.

Shortly after the larva has attained its definite independent form ten minute calcareous spicula make their appearance, imbedded within the external sarcode-layer of the expanded anterior portion of the larva. The ten spicula are arranged in two transverse rings of five, the spicula of the anterior row symmetrically superposed on those of the posterior. By the extension of calcareous network, these spicula rapidly expand into ten plates, which at length form a trellis enclosing a dodecahedral space, open above and below, within the anterior portion of the zooid. Simultaneously with the appearance of these plates, a series of from seven to ten calcareous rings form a chain passing from the base of the posterior row of plates backwards, curving slightly to the left of the larval mouth, and ending by abutting against the centre of a large cribriform plate, which is rapidly developed close to the posterior extremity of the larva. Delicate sheaves of anastomosing calcareous trabeculæ shortly arise within these rings, and the series declares itself as the jointed stem of the pentacrinoid stage, the basal and first inter-radial plates of the calyx being represented by the already formed casket of calcareous network. The skeleton of the Crinoid is thus completely mapped out within the body of the larva, while the latter still retains its independent form and special organs.

Within the plates of the calyx of the nascent Crinoid two hemispherical or reniform masses may now be detected—one superior, of a yellowish, subsequently of a chocolate colour; the other inferior, colourless and transparent. The lower hemisphere indicates the permanent alimentary canal of the Crinoid, with its glandular follicle; the upper mass originates the central ring of the ambulacral system, with its cæca passing to the arms. The body of the Crinoid is, however, at this stage entirely closed in by a dome of sarcode, forming the anterior extremity of the larva. After swimming about freely for a time, averaging from eight hours to a week, and increasing rapidly in size till it has attained a length of from 1 to 2 mm., the larva becomes sluggish, and its form is distorted by the growing Crinoid. The mouth and alimentary canal of the larva disappear, and the external sarcode-layer subsides round the calcareous framework of the included embryo, forming for it a transparent perisom. The stem now lengthens by additions of trabeculæ to the ends of the joints. The posterior extremity dilates into a disc of attachment. The anterior extremity becomes expanded, then slightly cupped; the lip of the cup is divided into five crescentic lobes, corresponding to the plates of the upper ring; and finally five delicate tubes, cæca from the ambulacral circular canal, are protruded from the centre of the cup, the rudiments of the arms of the Pentacrinoid. At some stage during the progress of these later changes the embryo adheres, and at length becomes firmly cemented to some permanent point of attachment.

The author states his views as to the morphological and physiological relations of the larval zooid. He believes that all the peculiar independently organized zooids developed from the whole or from a part of the segmented yolk in the Echinoderms, and which form no stage in the development of the perfect form of the species, must be regarded as assimilative extensions of sarcode, analogous in function to the embryonic absorbent appendages in the higher animals. For such an organism the term "pseudembryo" is proposed. In the Echinoderm subkingdom, although constructed apparently upon a common plan, these pseudembryos present considerable range of organization, from a somewhat complex zooid provided with elaborate natatory fringes, with a system of vessels which are ultimately connected with the ambulacral vascular system of the embryo, with a well-developed digestive tract, and in some instances with special nervous ganglia, to a simple layer of absorbent and irritable sarcode which invests the nascent embryo. The pseud-embryo of *Comatula* holds an intermediate position. It resembles very closely in external form and in subsequent metamorphosis the "pupa stage" of the Holuthuridæ, the great distinction between them being that in the Holothuridæ the pupa has already passed through the more active "Auricularian" stage, while the analogous form in *Comatula* has been developed directly from the egg.

West Kent Natural History and Microscopical Society.

February 18th, 1863.

List of Officers.

President.—Frederick Currey, Esq., M.A., F.R.S., Sec.L.S.

Vice-Presidents.—John Penn, Esq., F.R.S.; John F. South, Esq., F.R.C.S.; and James Glaisher, Esq., F.R.S., F.R.A.S.

Treasurer.—H. G. Noyes, Esq., M.D. Lond., M.R.C.P.L.

Hon. Secretaries.—Messrs. E. Clift and W. Groves.

Council.—W. H. Brown, Esq., F.R.C.S.; M. Corder, Esq.; William Groves, Esq.; W. G. Lemon, Esq., B.A.; Rev. R. H. Marten, B.A.; Flaxman Spurrell, Esq., F.R.C.S.: John Standring, Esq.; George Sweet, Esq.; James Taylor, Esq.; William Walton, Esq.; J. Jenner Weir, Esq.; Rev. J. G. Wood.

Report for the Year 1862.

Read at the Annual Meeting, February 18th, 1863.

Frederick Currey, Esq., President, in the Chair.

The council of the West Kent Natural History and Microscopical Society have the gratification of informing the members that the prosperity of the society, both in respect to numbers and finances, on which they felt they might justly congratulate them at the last general meeting, still continues to attend it. They have indeed to regret the loss of three of the former members, who have been removed by death, and the withdrawal of five others, whilst twenty-four new members have been admitted. And the council are rejoiced to see, in the lengthened list of names, a proof of increasing interest in the subjects the study of which the society seeks to promote.

The meetings during the past year have been well attended, and several of them have been rendered extremely instructive by the exhibition of various rare and novel objects connected with natural history or microscopical research.

A paper was read in October by James Glaisher, Esq., one of the Vice-Presidents, and a very crowded meeting, at which many ladies were present, listened to him with much pleasure as he detailed the particulars of his late balloon ascents, made at the suggestion of the British Association, and conveyed to his hearers, in a pleasing and popular form, and by the aid of excellent diagrams, the scientific results obtained by his aërial voyages. A paper also was read in March by J. Slade, Esq., giving an interesting account of "Shell Structure."

The past summer was not favorable for field-meetings; one only took place. The members who attended it were well pleased with the results. Botany was the science selected for illustration, and a list of about 240 plants met with in the day's excursion was drawn up by J. Mathewson, Esq.

The second *soirée* given by the society was held in June. About 300 ladies and gentlemen were present. More than fifty microscopes belonging to members were placed on the tables, and many objects of interest were exhibited. Among these were magnificent specimens of algæ and ferns from Australia and Japan; British birds' eggs; insects from various foreign countries, shells, &c.; with numerous fossils and other geological specimens. The room was beautifully decorated with choice exotics, lent by John Penn, Esq., and refreshments were supplied to the company.

The additions to the library during the past year have been—

Williamson's 'British Foraminifera.'
Carpenter's 'Introduction to the Foraminifera.'
Currey's 'Hoffmeister's Cryptogamic Botany.'
'The Microscopic Journal' for 1862.
'Popular Science Review' for 1862.
'Manchester Philosophical Transactions,' presented by the Manchester Literary and Scientific Society.

A cabinet has been purchased for the reception of microscopic slides, and more than fifty have been presented; and it is hoped that members obtaining any rare or interesting object will forward a duplicate for the use of the society. Soundings still continue to be received from various parts of the world, some of which have been examined, and several objects, especially Foraminifera, have been obtained from them.

The number of members is now 113, including eight honorary members.

The auditor's report will show that the funds are in a satisfactory condition.

Rules.

1. The society shall be called THE WEST KENT NATURAL HIS-

TORY AND MICROSCOPICAL SOCIETY, and have for its objects the promotion of the study of natural history and microscopic research.

2. The society shall consist of members who shall pay in advance 10*s.* 6*d.* each per annum, and of honorary members.

3. The affairs of the society shall be managed by a council, consisting of a president, three vice-presidents, treasurer, two secretaries, and twelve members, who shall be elected from the general body of ordinary members.

4. The president and vice-presidents shall not hold office longer than two consecutive years; and the two members of council who have attended the least number of meetings during the preceding year shall retire, and be ineligible for the following year.

5. The president and other officers and members of council shall be annually elected by ballot. The council shall prepare a list of such persons as they think fit to be so elected, which shall be laid before the general meeting, and any member shall be at liberty to strike out any or all of the names proposed by the council, and substitute any other name or names he may think proper.

6. The council shall hold their meetings on the day of the ordinary meetings of the society, one hour before the commencement of such meeting. No business shall be done unless five members be present.

7. Special meetings of council shall be held at the discretion of the president or vice-presidents.

8. The council shall prepare and cause to be read at the annual meeting a report on the general affairs of the society for the preceding year.

9. Two auditors shall be elected, by show of hands, at the ordinary meeting held in January. They shall audit the treasurer's accounts, and produce their report at the annual meeting.

10. Every candidate for admission into the society must be proposed and seconded at one meeting, and balloted for at the next; and when two thirds of the members present are in favour of the candidate, he shall be duly elected.

11. Each member shall have the right to be present and vote at all general meetings, and to propose candidates for admission as members. He shall also have the privilege of introducing two visitors to the ordinary and field-meetings of the society.

12. No member shall have the right of voting, or be entitled to any of the advantages of the society, if his subscription be six months in arrear.

13. That the annual meeting shall be held on the third Wednesday in February, for the purpose of electing officers for the year ensuing, for receiving the reports of the council and auditors, and for transacting any other necessary business.

14. Notice of the annual meeting shall be given at the preceding ordinary meeting.

15. The ordinary meetings shall be held on the fourth Wednesday in the months of October, November, January, February, March, April, and May, and the third Wednesday in December, at such

place as the council may determine. The chair shall be taken at 8 p.m., and the business of the meeting being disposed of, the meeting shall resolve into a *conversazione*.

16. Field-meetings may be held during the summer months at the discretion of the council; of these due notice, as respects time, place, &c., shall be sent to each member.

17. Members shall have the right of suggesting to the council any book or object to be purchased for the use of the society.

18. All books in the possession of the society shall be allowed to circulate among the members, under such regulations as the council may deem necessary.

19. The microscopical objects and instruments in the possession of the society shall be made available for the use of the members, under such regulations as the council may determine; and the books, objects, and instruments shall be in the custody of one of the secretaries.

20. The council shall have power to recommend to the members any gentleman, not a member of the society, who may have contributed scientific papers, or otherwise benefited the society, to be elected an honorary member; such election to be by show of hands.

21. No permanent alteration in the rules shall be made, except at the annual meeting, or a meeting specially convened for the purpose by the president, and then by a majority of not less than two thirds of the members present, of which meeting one month's notice shall be given.

ORIGINAL COMMUNICATIONS.

DESCRIPTIONS *of* NEW *and* RARE DIATOMS. SERIES X. By R. K. GREVILLE, LL.D., F.R.S.E., &c.

(Plates IX and X.)

RUTILARIA, nov. gen., Grev.

FRUSTULES free, elongated, compressed, with a convolute or nodulose central nodule (no median line or terminal nodule), and minute radiate or decussato-punctate structure. Valve (linear, keeled?) with a longitudinal row of puncta.

This is a most remarkable fossil genus, and its systematic position exceedingly perplexing. I have reason to believe that Mr. Kitton, of Norwich, who kindly sent me his cabinet specimens for examination, was the discoverer of the first species, which he obtained from the Monterey deposit, and named provisionally *Nitzschia Epsilon*, on account of the resemblance of the nodule to the Greek letter. But this nodule, conspicuous for its glistening appearance, as well as for its singular convolution, appeared to me to separate it from *Nitzschia*. Unfortunately no single valve occurred among the specimens found by Mr. Kitton and myself; and being unable with the instruments then in my possession to satisfy myself regarding the structure, I sent the specimens to my friend Mr. T. G. Rylands, who ascertained that the frustule was really Nitzschoid, in so far that the valves were keeled and furnished with a row of puncta. Still, the extraordinary nodule forbade its association with the true *Nitzschiæ*, and I laid the subject aside until further information could be obtained.

Recently two other diatoms have been discovered by Mr. C. Johnson in the Barbadoes deposit, which are evidently closely allied to the Monterey specimens, having the peculiar glistening nodules, Nitzschoid form, and marginal puncta. In these the intimate structure is more visible; the pale puncta distinctly radiating from the centre, and becoming decussate towards the ends. There can be no doubt, I think, that the three diatoms constitute a very natural genus. As I have been unable to ascertain positively whether the valves of the Barbadoes species are keeled (although I believe them to be so), I have inserted this character doubtfully. It will be perceived that I have framed the generic character on the assumption that this little group belongs, with *Nitzschia*, to the *Fragilarieæ*, and that the figures consequently represent the front view. But it must be confessed that, for a front view, the appearance is not a little strange.

Rutilaria Epsilon (Kitton), n. sp., Grev.—Frustule lanceolate, with linear, elongated, obtuse apices; nodule very large, with three conspicuous convolutions. Length ·0080″. (Pl. IX, fig. 1.)

Nitzschia Epsilon, Kitton, *in litt.*

Hab. Monterey deposit; F. Kitton, Esq., C. Johnson, Esq., R. K. G.

Frustules transparent, minutely and faintly punctate, the puncta forming decussating lines; margin with a row of dark, conspicuous puncta. Central nodule very glistening, large, occupying the greater part of the diameter of the frustule, composed of a semilunate body, with the horns, as it were, convolute, and having secondary horns arising out of and a little to the exterior of the others, also more or less convolute. A few large scattered puncta are generally present on each side of the nodule. Although there are no terminal nodules, there is sometimes the appearance of them, owing, apparently, to some peculiarity of structure influencing the transmission of light at the apices. The most remarkable feature in this diatom is the nodule, which, as a rule, is symmetrical, but here it is the reverse, and so whimsical in its configuration that it may be compared to some old-fashioned drawer-handle represented in *alto-relievo*.

Rutilaria ventricosa, n. sp., Grev.—Frustules ventricose, with short, linear extremities; nodule circular, nodulose; puncta radiating, decussate towards the ends. Length about ·0040″. (Fig. 2.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq., R. K. G.

A much smaller species than the preceding, and relatively shorter, but not unlike it in general form. The nodule, however, is quite different, being circular, with some appearance of being lobed or convoluted. The puncta distinctly radiate from the centre, until they reach the linear extremities, where they decussate. The extremities vary somewhat in breadth, and the apices are either obtuse or subacute.

Rutilaria elliptica, n. sp., Grev.—Frustules elliptical, with a slight contraction towards the acute apices; nodule circular, somewhat nodulose; puncta radiating, decussate at the ends. Length about ·0040″. (Fig. 3.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq., R. K. G.

The same size as the last, but well distinguished by its elliptical form.

Campylodiscus.

Campylodiscus undulatus, n. sp., Grev.—Disc nearly circular, with a linear, median space, and about 25 costæ on each side, which are separated by a longitudinal furrow into apparently two series. Diameter about ·0042″. Costæ 4 in ·001″. (Fig. 4.)

Hab. Bermuda, in mud brought up on the fluke of an anchor; kindly communicated by George Norman, Esq.

This species is nearly related to *Campylodiscus striatus* of Ehrenberg, figured by Mr. Brightwell in the seventh volume of the 'Journal of Microscopical Science,' but is, at the same time, abundantly distinct. It is a larger and much finer species, with nearly double the number of costæ, and in the character of the latter differing essentially. In *C. striatus* there are really two series on each side, the narrow hyaline space between them forming an actual interruption, while near each extremity of the median line they unite, a short line, at least, only passing between them. In our present species, on the contrary, the narrow hyaline space which divides the apparent two series of costæ is, in reality, a deep furrow, round the bottom of which the costæ are carried, as is easily seen towards each end, where, as the furrow becomes gradually shallow, the costæ are plainly continuous.

Grammatophora.

Grammatophora Moronenis, n. sp., Grev.—Septa straight; margin very coarsely striated; striæ 11 in ·001″. Length ·0025″. (Fig. 5.)

Hab. Deposit at Moron, in the Spanish province of Seville.

I have not seen the lateral view of this species, but in the small section of the genus characterised by straight septa the coarse striæ at once distinguish it.

Coscinodiscus.

Coscinodiscus scintillans, n. sp., Grev.—Disc with a circular umbilical space and radiating lines of small, distinct, brilliant granules, the long ones wide apart, with 2—3 short, very irregular intervening lines at the margin; margin striated; long lines of granules 4 or 5 in ·001; marginal striæ 15 in ·001″. Diameter ·0032″. (Fig. 6.)

Hab. Barbadoes deposit, from Cambridge estate; G. M. Browne, Esq.

A very beautiful species, which I have only observed in some slides which Mr. Browne obligingly sent for my inspection, the disc in question being one of the objects to which he particularly directed my attention. The great distance between the lines of granules which reach the centre is the leading character; and the very irregular intervening lines, varying in length from a couple of granules only, to a third of the radius, help to individualise it. The granules are singularly brilliant.

Coscinodiscus griseus, n. sp., Grev.—Disc gray, convex, depressed in the centre, with a somewhat indefinite umbilicus; granules equal, in close radiating lines; margin prominent, with a row of extremely minute puncta on its inner boundary. Diameter about ·0035″. (Fig. 7.)

Hab. Barbadoes deposit, from Cambridge estate; in slides communicated by C. Johnson, Esq.

I am not aware of any described species with which the present one can be confounded. But I am under an impression that one of the same colour, and in some other respects very similar, exists in the same deposit, differing, however, essentially in the presence of a row of marginal tubercles. There is an umbilicus in our present species, but it is generally more or less filled up with a little cluster of granules. The lines are crowded in the centre, more distinct as they approach the margin. The very minute puncta connected with the latter are easily overlooked.

Asterolampra.

Asterolampra Moronensis, n. sp., Grev.—Valve subcircular; areolated segments somewhat square at the base; umbilical lines with an angular bend, radiating from a central point; median ray narrow, the rest (6) linear, slightly dilated, and as if notched at the margin. Diameter ·0030.″ (Fig. 8.)

Hab. Deposit at Moron, in the province of Seville; G. Norman, Esq., R. K. G.

A very distinct species belonging to the section composed of Ehrenberg's genus *Asteromphalus,* characterised by one of the rays being much narrower than the rest, and by two of the radiating umbilical rays being approximated. It appears to have most affinity with *A. Darwinii* in the angular bend of the median lines, but in no other feature. In a general sense, the valve may be called circular; but it is not strictly so, for in the numerous specimens I have examined it is more or less unequal at the margin; so much so occasionally, as to have a somewhat cornered appearance. The umbilical lines are sometimes divided near their origin, as in *A. Brebissoniana* and *A. variabilis.* The rays are exceedingly well marked, by being invariably dilated at their marginal extremity, and by having the appearance of being notched, or as if a shadow indicated a funnel-shaped termination of the ray-tube.

Triceratium.

Triceratium Robertsianum, n. sp., Grev.—Valve with convex sides, obtuse angles, pseudo-nodules, and a wide hexagonal cellulation, the external row of cellules twice the size of the rest; those at the angles rounded and much smaller. Distance between the angles about ·0054″. (Fig. 9.)

Hab. Curteis Straits, Queensland; very rare; in a dredging communicated by Dr. Roberts, of Sydney.

This fine species belongs to the group of which *T. Favus* is the type, and which requires to be carefully studied, as the extent of variation in *T. Favus* itself is by no means clearly ascertained. In the rare diatom now before me there is no ambiguity, the outer row of large cellules being of a very remarkable character. The angles also are peculiar, the cellules which occupy them being rounded and much smaller, a vacant space being left immediately below the pseudo-nodule. The cellules in the centre are about 5 in ·001″. Those of the marginal row scarcely 3 in ·001″.

Triceratium prominens, n. sp., Grev.—Valve with straight sides, obtuse angles, and very prominent pseudo-nodules; centre slightly inflated; granules remote, large, in radiating lines, and increasing in size from the centre to the margin, where the lines are 4—5 in ·001″. Distance between the angles ·0040″. (Fig. 10.)

Hab. Barbadoes deposit, Cambridge estate; C. Johnson, Esq.

The granules are distinct and remote over the whole valve; not circular, but rather slightly quadrate, minute in the centre, but increasing in size as they radiate to the margin, which is striate. Pseudo-nodules vertical relatively to the plane of the valve, obtuse, and extremely prominent.

Triceratium disciforme, n. sp., Grev.—Valve nearly circular, with no perceptible pseudo-nodules; granules (rather cellules) very large, subquadrate, radiating, increasing in size from the centre to the margin, where the lines are 5 in ·001″. Distance between the angles about ·0035″. (Pl. X, fig. 11.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq., R. K. G.

In this curious species the valve is so nearly circular that the first specimen which came under my observation I took to be a *Coscinodiscus*. The angles, in fact, project so very little beyond the circular line as to be hardly perceptible, and are only discovered by looking for them. The structure is cellulate, but at the first glance seems coarsely granulate.

Triceratium cinnamomeum, n. sp., Grev.—Valve of a reddish colour, with slightly concave sides and obtuse angles, minutely punctate; puncta forming a line which projects from each angle fully half way towards the centre, while along the margin they are arranged in arch-like series. Distance between the angles about ·0030″. (Fig. 12.)

Hab. Deposit at Moron, in the province of Seville; G. Norman, Esq., C. Johnson, Esq., R. K. G.

This little species, which is not rare in the Moron deposit, is characterised invariably by its reddish-brown colour, and by the line formed by two rows of puncta, which projects inwardly from the angles. There are, besides, not unfrequently, three or four additional uncertain lines radiating very irregularly from near the centre. The latter, however, although evident enough in some examples, are scarcely perceptible in others. In the centre of the valve the puncta are not crowded. Towards the margin they are 18 in ·001″, arranged in more or less arched lines, which, under a power of 400 diameters, form a remarkable and conspicuous character.

Triceratium inflatum, n. sp., Grev.—Valve with very convex sides and somewhat obtuse angles, and several vein-like lines reaching from the margin about half way to the centre; surface with remotely scattered puncta, which become smaller and more numerous at the margin. Distance between the angles ·0035″. (Fig. 15.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq.

I do not know any described species to which this diatom can be referred. The central remotely scattered puncta are rather large, while those near the margin are minute. There is no pseudo-nodule.

Triceratium lineolatum, n. sp., Grev.—Valve with nearly straight sides, somewhat obtuse angles, and prominent pseudo-nodules; surface entirely filled with minute, uniform, radiating cellules, while 4—5 short vein-like lines project inwards from the sides. Breadth between the angles about ·0042″. (Fig. 16.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq.

Quite distinct from every species in this large genus. The vein-like lines are generally four on each side, and reach scarcely half way to the centre. Although the structure is minute, it is evidently cellulate under a power of 300 or 400 diameters.

Triceratium lobatum, n. sp., Grev.—Small; valve distinctly 3-lobed, with no perceptible pseudo-nodules; lobes ovate, having about 4 short vein-like lines on each side, and being more or less filled up with scattered puncta. Distance between the angles about ·0022″. (Fig. 13.)

A very beautiful and well-marked little species. The peculiar form is constant, resembling a 3-lobed leaf, while the short parallel lines may be compared to the veins. The puncta are not equally visible in all specimens, being sometimes irregularly scattered and most conspicuous near the margin; but in perfect examples the puncta (which, in fact, constitute a regular cellulation) are equally distributed over the valve, except in the centre, where there is a partially blank triangular space.

Triceratium denticulatum, n. sp., Grev.—Valve with concave sides and rounded angles; margin with numerous short, tooth-like striæ, the middle with a few minute puncta arranged in a triangular form, leaving the centre blank; towards the angles a few scattered large puncta. Distance between the angles ·0025″. (Fig. 14.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq.

In general form the frustule may be said to be slightly 3-lobed. The marginal striæ are very short and rather robust, forming an even line, except quite at the angles, which are left blank, but there is no pseudo-nodule.

Triceratium constans, n. sp., Grev.—Valve with straight sides, obtuse angles and small circular pseudo-nodules; whole area filled up with hexagonal cellules, about 5 in ·001″ in the centre, becoming smaller towards the margin. Distance between the angles ·0040″. (Fig. 17.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq., J. Ralfs, Esq., R. K. G.

A neat, well-defined species. The rather small pseudo-nodules filling up the slightly rounded angles are not prominent, but somewhat resemble the processes of an *Auliscus*. The cellulation becomes gradually smaller in approaching the margin, which is narrow, well-defined, and striated.

Triceratium tumidum, n. sp., Grev.—Valve with concave sides, very rounded angles, filled with large, oval, tumid, minutely punctate pseudo-nodules; surface with very remote, large, scattered puncta. Distance between the angles ·0042″. (Fig. 18.)

Hab. Barbadoes deposit, from Cambridge estate; C. Johnson, Esq.

Very distinct. The pseudo-nodules symmetrically rounded and prominent.

Triceratium Normanianum, n. sp., Grev.—Valve with the sides constricto-concave, angles dilated, widely hemispherical, with a transverse line at about one third of the distance between the lateral concavity and the summit; whole surface filled with minute puncta, those of the centre radiating. Distance between the angles about ·0030″. (Fig. 19.)

Hab. Barbadoes deposit, from Cambridge estate; G. Norman, Esq.

Unquestionably very near *T. castellatum* of West, but differing from it in the lateral concavities being far deeper and sharper, in the lobes or angles being more widely dilated, in the central puncta being radiate, and in the transverse lines which separate the angles from the centre being situated nearer the ends. It appears to be an extremely rare species, as it has only been seen by Mr. Norman.

Triceratium subcapitatum, n. sp., Grev. — Small; valve with straight or slightly convex sides, and very produced, slender, somewhat capitate angles, having a transverse line near the apex; surface minutely punctate, the puncta radiating, with 2—3 irregularly situated spines. Distance between the angles about ·0020″. (Fig. 20.)

Hab. Barbadoes deposit, from Cambridge estate; not unfrequent.

The nearest ally of this minute species is *T. capitatum* of Ralfs. That diatom, however, is almost hyaline, the central puncta quite obscure, while in the produced angles beneath the capitate extremity there are a few large puncta. On the other hand, in our present species radiating puncta occupy the whole valve; there is also a row of marginal puncta not to be seen in the other; the produced angles are narrower, and the apex much less rounded. With regard to the spines, I have seen sometimes two, sometimes three (doubtless the normal number), and sometimes have been unable to detect them at all. Whether in the latter case they had been broken off and left no trace, or whether they are occasionally undeveloped, I am unable to say.

Entogonia, nov. gen., Grev.

Frustules with the lateral view triangular, containing a central triangular figure, having a broad border divided by transverse costæ into punctate or cellulate compartments.

I propose this genus for the section of *Triceratium* of which for some time *T. marginatum* of Brightwell was the only representative. In my Series IV, ('Trans. Mic. Soc.,' vol. ix) I added six additional species, and in Series VII a seventh. Having now obtained four other species, I have been led to consider whether this most remarkable group ought not to be removed from *Triceratium* altogether. The species are exclusively fossil, and confined to the Barbadoes deposit. Their structure is quite peculiar, being composed of one triangle within another, the space exterior to the inner triangle being simply a very broad border, divided into compartments by transverse costæ. In the angles is a more or less complex arrangement of a pseudo-nodule, with a blank space immediately beneath it, and often various short lines. With regard to the species, it is impossible to say whether the characters I have selected for the diagnosis are permanent, as I am not aware of any analogy to guide me, and our knowledge of the whole group is very limited. There appear to be two natural sections, in which the species may be arranged as follows:

Sect. I. Central triangle blank.

Entogonia Abercrombieana, Grev.—*Triceratium Abercrombieanum*, Grev. 'Trans. Mic. Soc.,' vol. ix, p. 83, Pl. X, figs. 7—9.

Entogonia inopinata, Grev.—*Triceratium inopinatum*, Grev., l. c., p. 84, fig. 10.

Entogonia gratiosa, Grev.—*Triceratium gratiosum*, Grev., l. c., p. 85, figs. 12, 13.

Entogonia approximata, Grev.—*Triceratium approximatum*, Grev., l. c., p. 84, fig. 11.

Entogonia variegata, Grev. — *Triceratium variegatum*, Grev., l. c., p. 85, fig. 14.

SECT. II. Central triangle filled up with various markings.

Entogonia marginata (Brightw.), Grev.—*Triceratium marginatum*, Brightw., l. c., p. 82, fig. 5.

Entogonia pulcherrima, Grev.—*Triceratium pulcherrimum*, Grev., l. c., p. 82, fig. 6.

Entogonia amabilis, n. sp., Grev.—Valve with slightly convex sides and somewhat obtuse angles; the border compartments punctate; pseudo-nodule circular, very prominent; central triangle with slender radiating costæ, the angles penetrating a circular pseudo-nodular space. Distance between the angles about ·0042″. (Fig. 21.)

Hab. Barbadoes deposit, from Cambridge estate.

This is very similar to *E. pulcherrima* in the radiating costæ of the inner triangle, but the manner in which the outer angles are filled up is totally different. Instead of the oblong pseudo-nodule, with the lateral costæ continued round it, we have in the species before us a very prominent circular one, and no costæ passing round it at all; and instead of a pseudo-nodular blank space forming a continuation of the oblong outline of the pseudo-nodule, without any contraction between the two, we have a circular pseudo-nodular blank space immediately beneath the pseudo-nodule itself.

Entogonia venulosa, n. sp., Grev.—Valve with straight sides and obtuse angles; the broad border divided into punctate compartments by perfect and imperfect costæ; central triangle punctate, with a few radiating and transverse costæ; pseudo-nodular blank space somewhat cup-shaped, and separated from the pseudo-nodule. Distance between the angles about ·0032″. (Fig. 22.)

Hab. Barbadoes deposit, from Cambridge estate; G. Norman, Esq.

Perfectly distinct in the minutely punctate inner triangle, which is also traversed by a few costæ, those in the immediate centre radiating. It is peculiar, also, in the pseudo-nodular blank space being separated from the pseudo-nodule by a punctate compartment or band. The pseudo-nodule is roundish, and fills up the angles.

Entogonia Davyana, Grev.—*Triceratium Davyanum*, Grev., l. c., vol. xi, p. 232, Pl. X, fig. 4.

Entogonia conspicua, n. sp., Grev.—Valve with straight sides and sub-obtuse angles; compartments of the border with large, remote cellules; central triangle with smaller, radiating, oblong cellules; pseudo-nodular blank spaces transversely oblong; pseudo-nodules large, filling up the angles. Distance between the angles ·0025″. (Fig. 23.)

Hab. Barbadoes deposit, from Cambridge estate; G. Norman, Esq.

In this fine species we have, for the first time, the inner triangle filled up with cellules only, there being no veins or costæ in this part whatever. These oblong cellules do not form radiating lines, but they all occupy a radiating position. Those of the lateral compartments are more or less circular, large, and few (5 to 7 for the most part) in each. The pseudo-nodules are very large, filling up a considerable angle, minutely punctate, and in juxtaposition with the large, transversely oblong, pseudo-nodular blank spaces. The margin is striated, an exceptional character in the genus.

Entogonia punctulata, n. sp., Grev.—Valve with straight sides and obtuse angles; inner triangle filled up with minute radiating puncta; lateral compartments remotely punctate; pseudo-nodules large, rounded, having a hemispherical blank space at their base. Distance between the angles about ·0030″.

Hab. Barbadoes deposit, from Cambridge estate; G. Norman, Esq., R. K. G.

This species differs so obviously from the preceding that it is unnecessary to enter into a minute description. In general habit it resembles some of the species of the first section, but the punctate inner triangle and non-striated margin at once separate it. There is a very striking appearance of a pore at the outer extremity of each of the costæ which divide the border into compartments, a feature I have not observed in any of the other species.

On the Genus Callidina (Ehr.); *with the* Description *and* Anatomy *of a* New Species. By Henry Giglioli.

The genus Callidina was founded in 1830 by Ehrenberg, to receive the then only known species *C. elegans*, discovered by the Prussian zoologist himself in Berlin. This genus belongs to the *Philodinadæ*, and its members are characterised by the total absence of eye-spots, the smallness of their trochal disc, and the vivacity of their movements.

I intend to describe briefly the three known species, and to dwell more minutely on the fourth, which I discovered last winter, and believe to be new. Before commencing I feel it my duty to express my sincere thanks to Mr. Gosse, who contributed not a little to lessen the difficulties I encountered in working out the affinities of the last-mentioned species by the generous loan of his valuable drawings and MS. observations. I shall give the species in the order they were discovered and described.

*Callidina elegans,** Ehr.—Body spindle-shaped; trochal disc small. The digestive canal, which is figured filled with a dark-blue colouring matter, is a narrow, wavy tube, dilating distally, and *not occupying the whole breadth* of the granular mass which surrounds it; the mastax is very indistinctly figured, but in the text Ehrenberg describes it as being provided with *many* delicate teeth. The total length of the animal is ·37. It was first observed in a pond near Berlin.

Callidina constricta,† Dujard.—This species was first discovered at Toulouse, in 1840. Its mastax, according to Dujardin, presents "*une rangée de petites dents parallèles.*" The trochal disc is much constricted, whence its name.

Truly the characters of this species are very similar to those of the preceding one, the only difference being in the length, which here is ·5.

Callidina bidens,‡ Gosse.—This species was first observed by Mr. Gosse, in London, in 1849. He describes it as being spindle-shaped, $\frac{1}{45}$th of an inch in length, and possessing only two teeth in the mastax. Mr. Gosse expresses a doubt whether this may not be *C. elegans* of Ehrenberg, but the number of teeth is quite different. It is, however, more than likely that Dujardin's and Ehrenberg's species are identical.

None of the above-described species are parasites.

Callidina parasitica, mihi.—This species may or may not be distinct from the preceding one; I firmly believe it is. It certainly differs from *C. bidens* in its parasitism; moreover, many other minor differences exist, in the size and shape of different organs; but as it is no easy matter in these days to define the true characters required to constitute a species, I shall leave it to future investigators to decide.

Last winter, while engaged in examining the contents of

* Ehrenberg, 'Infusionthierchen,' p. 482, pl. lx, fig. 1.

† F. Dujardin, 'Infusoires,' p. 658, pl. 17, fig. 3.

‡ P. H. Gosse, 'Ann. and Mag. of Nat. Hist.,' vol. viii, 2nd series, 1851, p. 202.

the digestive and perivisceral cavities of *Gammarus Pulex*, in search of *Gregarinæ*, I first came across this species. At first I thought that I had got hold of a second entozoic Rotifer, and some time elapsed before I discovered my error, and that, instead of infesting the interior, it occurs as an epizoic parasite on the thoracic and abdominal appendages of *Gammarus Pulex* and *Asellus vulgaris*, inhabiting chiefly the branchial plates. It fastens itself on the bodies of these fresh-water Crustaceans by means of the two suckers placed at the extremity of its last caudal segment; it often changes place, crawling over the body of its victim in a leech-like manner. I have found this species in no other situation, not even on other freshwater animals or on aquatic plants; and though I have examined about seven or eight hundred Gammari from different localities, I have not found one free from these Callidinæ. On Asellus they are not so constant.

The body of *C. parasitica* is fusiform, and may be divided into a head, a neck composed of two false segments, a body or trunk consisting of one segment, and a caudal termination composed of six false joints (Pl. XI, figs. 1, 2). The penultimate caudal segment terminates in a pair of moderately large *claspers*; the last one terminates in a point, and supports two soft, cylindrical, protrusible appendages, which terminate distally in a sucker (fig. 8). In a specimen I measured they were $\frac{1}{3000}$th of an inch in length; that of the claspers being $\frac{1}{2000}$th of an inch.

The body is very transparent and colourless; no angular prominence exists on its central part, as in *C. bidens*;* the caudal extremity is comparatively long. *C. parasitica* does not swim much, as the preceding species, but it creeps a good deal, the proboscis and calcar being extended while the trochal disc is retracted. Its movements are precisely like those of a leech. It creeps in the following manner:—the suckers at the extremity of the tail fix themselves, the body is then stretched to the utmost, and its anterior portion is fixed (how, I was unable to make out); the tail is now drawn up, and the body contracted. All this goes on with great rapidity. The outer chitinous integument of the body or trunk is often thrown into strongly marked longitudinal rugæ; they generally appear when the creature diminishes the width of its body.

The *C. parasitica* differ much in size; the largest adult one I measured, when fully extended, was $\frac{1}{50}$th of an inch in length and $\frac{1}{500}$th of an inch in breadth; the smallest was

* P. H. Gosse, MSS., vol. iii, 1849, p. 9.

about $\frac{1}{100}$th of an inch in length and $\frac{3}{1000}$ths of an inch in breadth.

Muscular system.—On compressing the animal suddenly and violently, I saw several longitudinal and some transverse muscles (fig. 2), which were certainly not striated. Other muscles also exist, and often the tissues under the external integument contract within it, forming a sinuous outline, very likely under muscular action (fig. 1).

As in all *Philodinadæ*, the trochal disc is double, or rather bilobed; it is small, and surrounded by a single circlet of short cilia (fig. 2); it is rarely extended, the cilia continually vibrating, even when it is retracted. In small individuals the trochal disc is about $\frac{4}{1000}$ths of an inch across.

Digestive system.—In the middle of the trochal disc, on the ventral side, is a ciliated, protrusible, wedge-shaped proboscis, having at its extremity the oral aperture; it is not thick and rounded, as described by Mr. Gosse in *C. bidens*, and it never projects when the trochal disc is extended. The oral aperture (fig. 3) leads into a long, narrow, buccal funnel, richly ciliated internally (fig. 3), and dilated in the middle; it narrows again, and leads into the pharyngeal bulb or mastax, which is highly muscular, trilobate, and armed with a pair of moderately sized jaws, each possessing two teeth (fig. 3). A short œsophagus follows, leading into a large pyriform stomach (fig. 3), composed distinctly (as the rest of the intestine seems to be) of two membranes, the inner one supporting numerous cilia; it gradually narrows into the intestine, which has a bend on the left if the animal is considered in its natural position (fig. 1); the intestine gradually widens into a broad cloaca or rectum, richly ciliated, which opens externally on the left side of the dorsal aspect of the second segment of the tail (fig. 1) in a small anus, which is slightly protrusible, and not ciliated; the intestine also appears not provided with cilia. The particles of food are constantly undergoing a revolving movement in the stomach, as also the fæcal granules in the cloaca. In a large specimen the total length of the alimentary canal was $\frac{1}{80}$th of an inch; the pharyngeal bulb was $\frac{1}{900}$th of an inch in length and $\frac{2}{1000}$ths of an inch broad; the œsophagus was $\frac{1}{1000}$th of an inch long; the stomach $\frac{3}{1000}$ths of an inch in length; and the intestine was $\frac{1}{2000}$th of an inch in breadth.

Now, Mr. Gosse* considers in *C. bidens* the whole mass surrounding the alimentary canal, from beneath the mastax to where the intestine dilates and forms the cloaca, as the

* MSS., vol. iii, 1849, pp. 9—81, fig. 88 *e*.

digestive tube itself; as indigo swallowed, diffused itself throughout this mass: while I am positive that a distinct alimentary canal exists, as I have above described; at any rate, such is the case in *C. parasitica,* in which its walls are so tenacious that, having crushed accidentally one of these creatures, I had the pleasure to see nearly the whole alimentary canal float out free and disengaged from the granular mass which invests it, through the ruptured integuments.

No so-called *salivary* or *pancreatic* glands exist, and the substance surrounding the digestive tube is one homogeneous cellulous mass, of a yellowish-green colour, and even with the highest magnifying powers I could detect no follicules or cœcæ in its substance.

Water-vascular system.—This consists of a large, irregular, rounded vesicle, situated on the ventral side of the cloaca (fig. 2); it contracts rhythmically at regular intervals (about 30″); I could find no communication between it and the cloaca, or any special outlet of its own. Running into it, about its middle, are two extremely small, convoluted *water-vessels,* which run up along the sides of the body. I have traced them till under the trochal disc, in which I suppose they terminate cœcally. Even with one of Smith and Beck's largest first-class microscopes, with a linear power of 1300 diameters, I could make out no transverse branches or vibratile bodies, though they exist, no doubt. In fig. 2 the water-vessels are represented considerably larger in proportion than they really are.

Nervous system and sense organs.—Just beneath the trochal disc, on the left side of the ventral aspect of the buccal funnel, I saw in several individuals a small mass, which may be the ganglion, though I will not be sure about it. I could make out no ramifications proceeding from it, neither could I make out anything corresponding to the *ciliated fossa.*

The *calcar* (fig. 5) is large and well developed; it is not ciliated at its extremity (at least, with very high powers I could detect no such thing), but trilobate, the external lobes being more or less elongated. It is constantly protruded, feeling around, and is, beyond a doubt, a tactile organ. When the creature is contracted it appears on the median line (fig. 4), and when the trochal disc or proboscis is extended it generally appears on one side (fig. 2); it is rarely retracted as in fig. 1. No eye-spots exist in young or adult; and Mr. Gosse has observed that his *C. bidens* thrives well in the dark, but when exposed to a strong light it soon dies; this is very interesting, for many other animals are in the same predicament, and *C. parasitica,* living on *G. Pulex* and

A. vulgaris, which frequent the roots and under leaves of aquatic plants, exists necessarily in darkness. I do not know, however, if they perish when exposed to the light, not having made the experiment.

Reproductive organs.—As yet I have not met with a single male individual of this species; that is, I have not seen any not provided with an alimentary canal. I have observed many small ones without ovaries, but they were, doubtless, young. This is remarkable, considering the large number I have examined. The females have one or two ovaries, the latter number being the commonest; they are large, irregular, oval bodies, situated one on each side of the digestive apparatus (figs. 1, 2), and consisting of a finely granular mass, in which may be seen, more or less distinctly, germinal vesicles and spots (fig. 9). The length of an ovary I measured was $\frac{6}{1000}$ths of an inch, and its breadth $\frac{3}{1000}$ths of an inch. I could make out no distinct oviduct. An ovum, which could not have been long laid, measured $\frac{3}{1000}$ths of an inch in its long diameter, and $\frac{2}{1000}$ths of an inch in its short one (fig. 6). The ova, when deposited, adhere, by their posterior and smaller extremity (where the posterior part of the embryo's body is afterwards developed), to the appendages of the crustacean on which the mother lives (fig. 7).

Development takes place very soon; the egg, after the blastoderm is formed, assumes a somewhat pear-shaped form. In the largest ovum (fig. 7) the embryo is quite formed, the trochal disc is entire, and the ciliary action was going on most vigorously when I observed it; the mastax is distinct, and part of the alimentary canal can readily be made out. The length of the mature egg is $\frac{6}{1000}$ths of an inch; the breadth, $\frac{2}{1000}$ths of an inch. The enclosed embryo was $\frac{5}{1000}$ths of an inch in length.

I found nothing corresponding to *ephippial ova.*

In the neck and tail exist a number of what old authors thought to be glands, and which were very properly termed by Professor Huxley *vacuolar thickenings.*

NOTES on RAPHIDES.

By EDWIN LANKESTER, M.D., F.R.S.

THE term *Raphides* (from ραφις, a needle) was first applied by De Candolle to certain needle-like crystals found in the tissues of plants. The term has since been extended by some writers to all crystals found in plants, whilst others, adhering to the etymology of the word, apply it only to crystals of an acicular form. Schleiden discards the word altogether, and perhaps it would be better to get rid of a term which has neither accuracy nor utility to recommend it. The discovery of crystals in plants is due to Malpighi, who first figured crystals found in a species of Opuntia in his 'Anatomy of Plants.' The needle-like crystals were afterwards described by Rafn as occurring in the milky juice of the Euphorbiaceæ. Jurin found the same kind of crystals in the leaves of *Leucojum verum*. Raspail was the first to demonstrate that many of these crystals were oxalate of lime—a fact that Scheele had demonstrated with regard to the crystals found in the roots of the common rhubarb. The most elaborate and complete paper on this subject was published by Edwin Quekett, and appeared in the appendix to the third edition of 'Lindley's Introduction to Botany' in 1839. Since that time various observers have published observations on this subject. The late Professor John Quekett, in a paper in the 'Microscopical Transactions,' showed that many of these crystals had an organic basis. Mr. Rainey, in his 'Researches on the Mineral Structure of Vegetable and Animal Cells,' has contributed many observations on the presence of crystalline matters in vegetable cells. In the January number of the 'Annals of Natural History,' Professor Gulliver, in a paper "On the Raphides of British Plants," says: "It appears to me that these raphides are deserving of more attention than they have yet received both in relation to the structure and economy of vegetables, and as affording a wide, interesting, and scarcely cultivated field of research for the chemical phytologist." These raphides, he adds, "may also be often useful as diagnostic characters in systematic botany when others are not available; for example, a mere fragment of one of the Onagraceæ or of the Lemnaceæ may be so surely distinguished simply by its raphides from some of its near allies in other orders, that this fact ought henceforth to be added to the description of the orders just mentioned, independently of its value in other respects." "Though common in some orders, it is remarkable that the raphides are so rare where they might be most expected, that I have not a single note of their presence in young parts of the stem, leaves, and flowers of British Oxalidaceæ, Umbelliferæ, Labiateæ, Euphorbiaceæ, or Polygonaceæ, and even among Crassulaceæ. No crystals were found in *Sedum Telephium* and *S. acre*."

There can be no doubt of the important part that mineral substances play in the organization of both plants and animals, but the composition of these mineral matters, especially in plants, is but imperfectly known. The method most relied upon for ascertaining their nature has been chemical analysis, but where this has been resorted to, after the destruction of the tissues of the plant by exposure to heat changes take place in the composition of the minerals, which render this method very uncertain. Fourcroy and Vauquelin, as long ago as 1809, showed that the greater part of the carbonates found in the ashes of plants were formed during the burning from other salts of vegetable acids. They proved that almost all plants contain acetate and malate of lime dissolved in the sap, also citrate, tartrate, and oxalate of lime, either dissolved or in a solid form. Certain elements are also expelled by heat, as chlorine, so that chemical analysis alone does not give us a satisfactory explanation of the composition of mineral compounds in plants. The careful use of the microscope seems to offer a more satisfactory means of ascertaining really what the nature of these substances is. A large number of the salts present in plants are insoluble, and they present slender crystals in the tissues of plants, and it is these which have been observed by the microscope and called Raphides. Even with regard to the soluble salts, their forms might be made out by the evaporation of the juices in which they are contained, in the same way as has been so successfully pursued in making out the salts of the blood and urine. There can be no doubt that this subject affords an inviting field for research, and would amply repay investigation. The researches of Mr. Attfield on the nature of the efflorescence found on medicinal extracts show what may be done in this direction. The fact that so large a number of these crystalline productions are composed of chloride of potassium is very interesting, as pointing to the probability that the form in which potassium exists in land plants is really that of a chloride, and that the carbonates of potash obtained from the ashes of land plants are formed in the same way as the carbonates of soda from the sea plants, which contain chloride of sodium. The extent of our knowledge of the forms in which the soluble salts of plants exist is very limited; the recorded facts with regard to the salts which are insoluble are much more extensive; at the same time the number of those which have been observed is not large.

The most common of the insoluble salts is undoubtedly the *oxalate of lime*. Schleiden says it appears to be present in every plant, but this is undoubtedly an error. The statement of Professor Gulliver with regard to the absence of raphides in certain plants contradicts this assertion; and what is very curious in his observations, is the fact that he has not been able to discover these crystals in the British Oxalidaceæ. The acidity of the Oxalis has been usually ascribed to the presence of oxalic acid; and if this be true, it is certainly very strange and curious that the oxalate of lime should not be found in these plants. The oxalate of lime occurs in two principal forms. First, as large, single crystals, which are either elongated prisms, or octohedrons. They are frequently more or less rounded, or assume a dumb-bell form, arising from their crystallizing in contact with organic matters, as occurs with many other forms of crystals. Such rounded bodies are seen in the milky juices of plants, and have been regarded by Schultes and others as possessing vital properties of much importance in relation to the growth of the plant. Secondly, in the form of groups of crystals. In this form they are frequently developed upon an organic basis, and have been called by Meyen and others crystal glands. It is to some of these compound crystals that Weddel applied the term *Cystolithes*.

With regard to the form assumed by these crystals there has been some difference of opinion. Quekett took some pains to discover their exact form, and says, "That the four-sided is the ultimate form of these minute crystals is rendered more probable by the occurrence of rhombohedral and rhombic prisms, without pyramids of the same composition in the same plant, but of much greater widths; and there can be no doubt that these latter bodies and the acicular are two modifications of crystal of the same substance. The most decided proof of their being four-sided is obtained by pressing lightly on the piece of glass which covers them whilst examined under the microscope, when those which appear six-sided instantly appear four-sided, owing to the square crystal resting obliquely."

The acicular crystals, to which the name raphides have been more particularly applied, have been often described as having the same composition as the larger single and compound crystals. They are prismatic in shape, and lie together in bundles of from twenty to thirty in a single cell. They are sometimes enveloped in a gummy matter, which, on being moistened, distends and bursts the cell in which they are contained, and the crystals escape at both ends: such cells have been called *Biforines*. E. Quekett was one of the first to point out that these crystals consist of *phosphate of lime*. He says, if heated red hot they do not dissolve in acids with effervescence—a fact which essentially distinguishes them from the oxalate-of-lime crystals. The acicular crystals appear to be much more abundant than any other kind. This fact is interesting in connection with the supply of phosphate of lime to the animal kingdom, and the existence of these acicular crystals may be made to indicate the value of plants which possess them, as food for man and domestic animals.

Next to the oxalate and phosphate of lime in frequency comes *carbonate of lime*. It assumes a variety of forms, but is most frequently found in that of a pure rhombohedron. Crystals of carbonate of lime are often found with those of oxalate of lime in the Cactaceæ. I have found it in every part of the structure and on the surface of *Chara hispida*.

The next salt of lime which has been described as present in the tissues of plants is *sulphate of lime*. It is found in the form of double or single octohedrons, or in a tubular form, as octohedrons above and below, with the end of the prism obtuse. They even occur in a twin form, like the gypsum crystals from Montmartre. They are found, according to Schleiden, in Musaceæ and Scitaminaceæ.

Quekett refers to the presence of crystals in the fruit of the grape as differing from those in the leaves. These may be tartrate of lime. We might also expect here bitartrate of potass. Any of the less soluble combinations of the organic acids with the bases magnesia, potash, and soda, might be found with the aid of the microscope.

Although *silica* is not usually enumerated by writers on raphides and crystals in plants, it must evidently be regarded as one of the most important of the mineral constituents of plants. I find nowhere any observations on silica in plants in the form of crystals, although Quekett, Schleiden, and others, speak of crystals of silica as occasionally found. The presence of silica seems essential to large groups of plants. As every one knows who reads the 'Quarterly Journal of Microscopical Science,' the Diatomaceæ are almost entirely constructed of it. It forms the framework of the Equisetaceæ. Schleiden gives the following per-centage of silica in the ashes of species of Equisetum:—*E. limosum*, 94·85, *E. arveuse*, 95·48, *E. hyemale*, 97·52. A complete mould in silica of the whole structure of these plants may be obtained by treating them with nitric acid. The palms contain large quantities of silica in their stems. Lumps of silica, called tabersheer, are found in the interior of some of the palms. The ashes of *Calamus rotang*, according to Jablons, yielded 97·20 per cent. of silica. John Quekett, in his lectures on 'Histology,' has given illustrations of the presence of silica in the glumes and paleæ of the cereal grasses. One of the most interesting instances of the presence of silica amongst exogenous plants is that of the stellate spicules on the under surface of the leaves of *Deutzia scabra*. This very exceptional case shows that the appropriation of these mineral substances is no mere general function of plant structure, but that it is the result of the special organization of the plant.

The position of raphides has been a subject of controversy. Raspail, who wrote on them in his usual wrong-headed way, asserted that they were never found in the interior of cells, but always in intercellular passages. Of course this was easily refuted, but the converse was not true, that they are always found in cells. The fact is, they are found in both positions, and even in the free surfaces and in the spiral vessels of plants. They have been found by Quekett loose in the anthers, mixed with the pollen in *Hemerocallis purpurea*, *Anigozanthus floridus*, and other plants. Of all the parts of plants in which crystals are found, the stems of herbaceous plants are the most common. They are, however, found in the tissues of all parts of plants. Observations are wanting on the presence or absence and comparative numbers of these crystals at different periods of the growth of plants. Professor Gulliver says, that "in old, decaying, or diseased portions of Polygonaceæ, and in many other orders, crystals are frequent." Observations on these would be interesting, as affording indications of the mineral composition of the living plant.

Professor Gulliver has given an account of his observations on raphides, as they occurred in order. It would be of value to know what crystals are found in particular orders; it would throw light on the functions of plants, and explain some of their economy. Already we know that some plants grow on chalk soils, others on clay soils, whilst some again require phosphoric acid, and others potassium or sodium in excess. A minute analysis of crystals by the microscope may lead to a better system of manuring for cultivated plants than any that have yet been suggested from the misleading analyses of the ashes of plants.

The following are the orders and plants, as far as I can find, in which raphides and crystals have been found :

CRYPTOGAMIA.

ALGÆ.—*Nostoc Muscorum, Conferva crystallifera.* Chætophora, Hydrurus, Polysperma, and Spirogyra.

CHARACEÆ.—*Chara hispida.*

EQUISETACEÆ.—Silica in the walls of cells of several species of Equisetum.

ENDOGENÆ.

LILIACEÆ.—Species of Aloe. *Scilla maritima.* Bulbs of onion. *Endymion nutans,* in all parts of the plant (Gulliver.)

BROMELIACEÆ.—*Agave Americana.*

ARACEÆ.—*Calla Æthiopica, Caladium esculentum, Dieffenbachia Seguina.*—Professor Gulliver says that he finds raphides throughout the plant in *Arum maculatum.*

IRIDACEÆ.—In *Iris pseudacorus,* long prismatic crystals in leaves (Gulliver).

TYPHACEÆ.—In *Sparganium ramosum* and *S. simplex,* in the perianth, fruit, stem, and leaves.

LEMNACEÆ.—Raphides most abundant in *Lemna trisulca* and *L. minor,* but comparatively scanty in *L. polyrhiza* and *L. gibba.* In *L. minor* abundantly, associated with starch granules (Gulliver).

CYPERACEÆ.—Meyen and other observers have found raphides abundant in *Papyrus Antiquorum.*

MUSACEÆ.—Crystals of sulphate of lime have been found in *M. Paradisaica* and other species of Musa, also in the order SCITAMINEÆ.

ORCHIDACEÆ.—In *Epidendrum elongatum* (Lindley), and in *Orchis Morio, O. mascula, O. maculata,* and *Habenaria chlorantha* (Gulliver).

EXOGENÆ.

CACTACEÆ.—All the forms of oxalate of lime have been recorded in this order. Quekett especially mentions *Opuntia crassa,* and Lindley *Cactus Peruvianus.*

ONAGRACEÆ.—Gulliver says that true raphides occur in such abundance in this order as to be quite characteristic, especially in the netted-veined group. He adds that they occur in all parts of these plants, so that a minute fragment of any of them will serve to distinguish them from Lythraceæ and Haloragaceæ. In the latter order Schleiden says they have been found in Myriophyllum, in the cells and in the glands of the air-passages.

CARYOPHYLLACEÆ.—The only species in which they have been found by Gulliver is the *Silene Armeria.*

OROBANCHACEÆ.—Schleiden says that crystals of carbonate of lime are found in *Lathræa.*

SAXIFRAGACEÆ.—Crystals have been observed as excretions in the edges of the leaves in *Saxifraga Aizoon* and *S. longifolia.*

NYCTAGINACEÆ.—Lindley mentions the existence of raphides in great abundance under the cuticle of the *Mirabilis Jalapa.*

LEGUMINOSÆ.—But few instances are recorded of crystals in this large order. Professor Bailey is quoted by Balfour as having found them in great abundance in Locust bark.

CAPRIFOLIACEÆ.—Meyen found an abundance of crystals in the bark of *Viburnum Lantana.*

TILIACEÆ.—Quekett says he has observed two kinds of crystals in the bark of the lime (*Tilia Europæa*).

EUPHORBIACEÆ.—In the milky juice of these plants crystals are recorded as occurring, by several observers. Quekett says he has found them in cascarilla bark.

VITACEÆ.—The bark, leaves, stipules, and fruit of the common grape contain crystals of more than one sort (Quekett).

POLYGONACEÆ.—The various species of Rheum contain oxalate of lime, more especially in their roots.

JUGLANDACEÆ.—Flattened prisms in hiccory bark (*Carya alba*, J. Quekett).

GALIACEÆ.—Gulliver found raphides in the ovary, corolla, leaves, and other parts of *Sherardia, Asperula,* and six species of Galium. They are common in the corolla and young fruit, but scanty in other parts of *Galium Mollugo.*

COMPOSITÆ. — Professor Gulliver says of this order, "Raphides are less common in this order than other crystals, and I have only found them in the ovary or fruit. They were seen in Corymbifera, Cynarocephalæ, and Cichoraceæ. In *Pulicaria dysenterica* single oblong crystals, with angular-pointed ends; in *Senecio Jacobæa* and *S. aquaticus,* short, acicular crystals; in *Arctium intermedium* and two other species, cubical crystals, $\frac{1}{3000}$th of an inch diameter; in *Centaurea nigra,* single and double crystals, shaped like those of Pulicaria; in *Carduus lanceolatus, C. palustris,* and *C. acaulis,* some acicular forms, and a greater number like those of Pulicaria and Centaurea; in *Hypochæris radicata, Apargia autumnalis,* and *Crepis virens,* minuter square or cubical crystals."

Urticaceæ.—In the milky juice of *Ficus elastica;* in the tissues of *Parietaria officinalis* (Henfrey). Single crystals in the bark of the common elm (*Ulmus campestris,* J. Quekett).

Pomaceæ.—Bark of the common apple-tree (*Pyrus Malus,* J. Quekett).

Elæagnaceæ.—Pith of *Elæagnus angustifolia* (J. Quekett).

Coniferæ.—E. Quekett mentions crystals in the bark of *Araucaria imbricata.*

Cinchonaceæ.—In the barks of the various species of Cinchona (E. Quekett).

Phytolaceaceæ.—*Phytolacea decandra.*

Cycadaceæ.—Compound crystals in the stems (Schleiden).

Dioscoreaceæ.—Raphides plentiful in the stem and leaves, and still more in the perianth and stamens of *Tamus communis,* Gulliver.

I have given the above summary as far as the materials within my reach will enable me. I know it is very imperfect, but I believe, with Professor Gulliver, that the subject is deserving of more attention than it has yet received, and offers a capital field of investigation for the microscope. Mr. Gulliver has set a good example in detailing the facts which he has recorded in the life-history of our common plants. The biography of our indigenous plants has yet to be written, microscope in hand, and it is not till the minute details of the cell-life of each plant has been recorded, that we shall be in a position to arrive at the laws which govern the life of the vegetable kingdom.

Before concluding, I would add a remark or two on the uses of raphides. Link first propounded the notion that the raphides were an abnormal condition, and resembled calculi in animals, and Edwin Quekett regarded them as accidental deposits. He succeeded, in fact, in forming artificially oxalate-of-lime crystals in rice-paper, by immersing it first in oxalate of ammonia and then in lime-water. This experiment, indeed, showed that the formation of these crystals might be the result of chemical laws, but it did not show that the chemical force was not counteracted by other forces connected with special conditions of the plant. Professor Gulliver's observations with regard to the Lemnas are especially interesting, as showing that plants closely connected in structure, and living under the same external circumstances, nevertheless produced these crystals in very different quantities. The persistence of the same crystals in the same plants clearly indicates that there is a relation between these bodies and the life of the plant.

Some physiologists regard the raphides as representatives of a skeleton in the animal kingdom, and I recollect, in 1837, Professor Grant, in his lectures at University College, drawing a comparison between raphides and the siliceous spicules of the sponges. When we consider the functions of the siliceous deposits in so large a number of plants, I think there can be little doubt that, in many cases, these mineral deposits perform the same functions in the plant as in the animal. At the same time, just as we find a large number of mineral compounds in plants which do not subserve the purposes of a skeleton, so in plants many of these mineral substances probably perform this and even more important functions in the life of plants.

What these are it is for careful observation to point out. It is not sufficient that we know that certain mineral compounds are necessary for the life of plants, but what we require to know is how particular mineral compounds are necessary to the life of plants, and the nature of the vital processes which are thus affected by these agents.

Some ACCOUNT *of* PROTOPLASM, *and the part it plays in the* ACTIONS *of* LIVING BEINGS. By A. B. DUFFIN, M.D., Assistant-Physician to King's College Hospital.

IT will not be seriously contested that, of the constituents of the cell, the so-called "protoplasm" is deserving of particular attention, from its liability to change, its activity, and the marked manner in which it participates in the vital phenomena of living structures. Since the publication of H. v. Mohl's remarkable work, the botanists have long arrived at the conclusion that, not only the formation of the cell-membrane, but also the inner nutritional changes of the cell itself, primarily depend upon the protoplasma.

As early as 1861* Max Schultze insisted upon the necessity of a modification of the views generally entertained respecting the relation of the cell-membrane to the cell-contents, and to the so-called intercellular substance of animal structure, and he argued in favour of a higher position for that part of the cell which corresponds to the protoplasm of Mohl. He at the same period pointed out how materially a careful study of the phenomena presented by the pseudopodia extended by the various Rhizopoda might assist in

* "Ueber Muskelkörperchen," Reichert u. Du Bois Reymond's 'Archiv,' 1861.

elucidating the life of the essential cell elements. Unger* had been already struck with the close similarity of the mobile phenomena of the Polythalamiæ with those of the processes of protoplasm stretched across the cavity of many vegetable cells. Although he had not personally investigated the former, he became convinced, from Schultze's description, that a resemblance amounting to identity existed between their movements and the protoplasm streams of many vegetable cells. Shortly prior to the appearance of Unger's work, Pringsheim,† in opposition to the theory of the primordial utricle then prevalent, insisted that everything that lay within the cell-membrane of a living vegetable cell might have a complex disposition, but consisted essentially of nothing but protoplasma and cell fluid. He admitted that in the cortical layer of the protoplasma a distinct arrangement into layers often occurred, and these he distinguished as the cutaneous and granular layers of the protoplasma, but he denied that the primordial utricle could be differentiated as a membrane from the subjacent protoplasm. If in animal cells, partly from their relatively smaller size and partly from their greater average wealth in protoplasma, it is more rarely possible to make a sharp demarcation between a cortical layer of protoplasm and a cell-fluid, there nevertheless exists a difference in the constitution of the former, such that a cutaneous layer, destitute of or scantily supplied with granules, encloses the remaining more granular material. The white blood-cell may serve as an example. This is, however, very different from a proper membrane.

To pass on to some account of the movements presented by the pseudopodia of the Foraminifera. Max Schultze ‡ describes them as threads of a transparent material rich in granules, presenting a high degree of variability in their shape and length. They pursue a diverging course, divide at acute angles, and unite to form a kind of network. They are constantly in motion, lengthening, shortening, subdividing, uniting. They are also the seats of an inner activity which affects even those fibres that are subject to none of the above-named changes. This inner activity is the so-called granule movement. It is a gliding, a flowing of the granules contained in the substance of the filaments. With a greater or less velocity they travel either to the periphery or to the root of the thread, often, even in the thinnest threads, in both directions simultaneously. When granules happen to meet, they

* 'Anatomie u. Physiologie d. Pflanzen,' p. 280, 1855.

† 'Untersuchungen über d. Bau u. d. Bildung d. Pflanzenzelle,' 1854.

‡ 'Das Protoplasma der Rhizopoden und der Pflanzenzellen' von Max Schultze, 1863.

either pass each other or move round each other till, after a short interval, each pursues its original course, or the one carries the other away with it. They often stop in the midst of their career, and then return, but the majority reach the extreme ends of the threads, and only then change their direction. All the granules of a thread do not move with the same velocity, but the one may overtake the other. Where several threads coalesce, the granules may be observed to pass from the one to the other. As such spots move, extensive collections of the material composing the filaments may be found, and from these fresh independent processes may originate. Many of the granules run evidently quite on the surface of the threads, over which they may be distinctly seen to project. In addition to the small granules, large collections of material resembling spindle-shaped swellings or lateral intumescences may occasionally be seen moving in the same manner as the granules. Even extraneous bodies which may chance to adhere to the filament may participate in this movement.

That this remarkable movement of granules should be brought into some relation with the contractility of the substance of the pseudopodia has never been questioned, since we have no other expression wherewith to designate the inner cause of independent animal movement than contractility. As it is evident that the granules have no active faculty of locomotion, but obey the impulses of the basic material, this last must of necessity be considered as in a state of flowing motion.

That a filament may lengthen, large masses of substance must change their place, and this can often be watched in the larger advancing nodules. If this great change in position be admitted for larger portions of the substance of the pseudopodia, it is obvious that such a change of locality cannot be denied for smaller portions of it. Thus, the expression flowing movement of the basic substance is to be explained, which, at the same time, gives some indication of the peculiar consistence of these contractile pseudopodia which so closely resembles that of a fluid.

Reichert* has objected that in the substance of pseudopodia of the Polythalamiæ no granules exist, but that they are an optical delusion, derived from waves on the surface of the filaments, being mistaken for granules in their substance. Against this, Max Schultze argues: 1. The sharp definition and decided lustre of the bodies in question do not speak in favour of their being only parts of the substance of the

* 'Monatsberichte d. Akad. d. Wiss. zu Berlin,' pp. 406—426, 1862.

filaments, as Reichert himself admits—that this has little more refracting power than the surrounding water. Granules which project literally from a thread pass into luminous points when the tube is lengthened beyond that position in which the movements are best observed. 2. With a high power it will be seen that many of the granules circulating in the threads of the Miliolides have an oval or staff-like shape, and although the majority of them have their long axis parallel to that of the thread, they not unfrequently lie at right angles to some, only to roll over as they move onwards. In short, these bodies often rotate, and this proves their corpuscular nature. 3. Reichert argues that the granular appearance vanishes whenever the threads are extended in a quiescent state, but Schultze notices the extreme rarity of this phenomenon, and asserts that, however thin the filaments, seldom more than a second passes without a granule coursing along it from some neighbouring thread. These extended fibres in a quiescent state are just those that show the most vivid play of the granule circulation. Frequently a few granules may be seen to rest for a short while, as at the so-called bridges, when these chance to stand at right angles to the filaments they happen to unite. By artificial means the granules may be brought to rest over considerable tracts without, as Reichert supposes, any disappearance of them. If a drop of distilled water be placed at the margin of the glass covering an animal with its pseudopodia extended, the movement of the granules becomes sluggish, and ultimately stops without any other change being noticed in the filament; the granules are as distinct and numerous as before; the basic substance appears totally unchanged. Should the influence of the distilled water be continued, small vacuoles appear in the substance of the filament, enlarge, spread, and acquire a frothy appearance, till the whole is destroyed by the increasing phenomena of imbibition. Similar results may be obtained from solutions of iodine, weak acids, or alkalies, and the electric current. The objection that the phenomena of coagulation disturb the observation is met by the following experiment. If an animal with extended pseudopodia be crushed so that its capsule bursts and the contents are extruded in dense masses, the extended threads, wherever they are not mechanically incommoded, lie unchanged, and retain their characteristic movements for a while. Although their connection with the body of the animal has been in many cases severed, the circulation of the granules persists. But it becomes more and more tardy, the filaments contract more and more to dense networks or extended aggregations, whence a few fresh threads may issue, but in these the movement of the granules ultimately ceases. Nevertheless the granules in the substance of the threads are as distinct as before, till the diffusing influence of the water gradually dissolves the whole.

In order to give a clear insight into the consistence of the substance of the pseudopodia, Schultze places a Miliolide in the object-holder, with its pseudopodia extended. He then notices that all the filaments that are lengthening rapidly and in a straight line are rounded at their extremities so as to form nodular swellings, either globular, heart-shaped, or cylindrical. This terminal swelling is granular, like the rest of the filament, and the granules are, like itself, in a constant tremulous movement. The nodule advances as if feeling its way, inclining hither and thither, and fresh granules continue to flow in from the base of the thread, whilst others retire along it. If the filament has advanced some way without encountering any obstacle, it curves round, often at a tolerably right angle, and moves now in the new direction as if aware where to find other radiating pseudopodia. The instant it touches a neighbour, the nodular end breaks up like a vesicle full of fluid, and mingles its contents with those of the filament it has encountered. When a broad filament meets a narrow one it will coalesce with it, but pursue its original course for a while, as if undisturbed. It is frequently to be observed that just as one is expecting approaching fibres to coalesce, they pass close to each other in different planes. The coalescence does not ensue even on direct contact. Consequently either an act of volition must assist, or an obstruction has to be overcome, as when two drops of oil will only flow together on being pricked with a needle. That volition comes into play is evident, since the filaments of different individuals never unite, but retreat from each other as from a determined foe. The passage of a granule from one filament to another may be considered as conclusive of their coalescence. It is very interesting to feed these animals on carmine. The granules adhere to and circulate within the pseudopodia, and the more minute the particles the more rapid the motion. Some glide towards the peripheral end of the filament; the majority are received into the interior of the creature. One granule of carmine overtakes the other, and if two meet, the one carries the other with it. Schultze has even known masses of carmine produced by the adhesion of many small ones to be dragged away, although ten times the diameter of the threads. Even those threads in which a centripetal stream is most marked, not only do not shorten, but either retain their dimensions, or continue to elongate. Similarly the centrifugal current persists in a retracting filament. These experiments show the very slight consistence of the surface of the pseudopodia, that the movement of the granules may be compared to a current, and further they afford us a means of ascertaining what part of the animal is destined for the reception and digestion of nourishment.

The consistence of the pseudopodia is, however, liable to considerable variations in different kinds of Rhizopods. The relation is the same as in the protoplasm of different cells or of the different parts of a cell. Among the Gromidæ the extremes are best observed in *G. oviformis* and *G. Dujardinii.** The latter is characterised by the completely hyaline character of the threads it emits. They are very torpid in their movements—so rigid and firm, as to show no tendency to flow together even on contact. They present no movement of their substance that can be compared with the granule motion, still there is no evidence of their being composed of loosely-aggregated threads. In *G. oviformis,* on the contrary, the whole mass of the pseudopodia is uniformly granular and diffluent. Many of the Miliolides occupy a position intermediate to the two varieties of Gromia. But even in the same animal firmer and more fluid hyaline and granular substance may occur together in the pseudopodia. Just as in many Amœbas a hyaline cortex encloses the granular interior, and the two constitute the Amœba, so there are pseudopodia the axis of which is a hyaline, and, it would seem, firm thread, on the surface of which the granular, softer material moves about. This is the case with *Actinophrys Eichhornii.* The pseudopodia have so little movement that they look like hard spines; still they consist of a contractile material. Curves and coils are occasionally met with on them, and they possess the faculty of retraction, but all changes of shape occur very slowly. They are also endowed with the granule movement, but this is restricted to the cortical substance. All the radiating filaments arise by means of their hyaline axis from the interior of the body of the animal, but the movable granular cortex comes distinctly from the cutaneous layer of the Actinophrys. It is further remarkable that several axial filaments, arising close together, but from distinct points on the medullary substance, may be apposed so as to constitute a common fibre. This union generally occurs during their course through the cortical

* 'Ueber d. Organismus d. Polythalamiæ,' taf. i and taf. vii.

substance, but may only ensue when they have quitted the body of the animal. The lines of contact do not always totally disappear. These compound radii are always enclosed by a common sheath of the soft granular mass. Should the axes only unite outside the body, the soft coverings of each will coalesce, whilst the finer hyaline axes run side by side, without becoming agglomerated. Thus *Actinophrys Eichhornii* appears to contain in its pseudopodia both those substances that are found separately in *Gromia oviformis* and *Dujardinii.* The application of artificial means further illustrates the structure of the pseudopodia of Actinophrys. If moderate pressure be exerted on the animal so as to flatten it, the pseudopodia will be slowly drawn back. The granular cortex melts together to little, spindle-shaped nodules, and the previously smooth fibre appears varicose. The fibre continues to retreat, and may become curved. Whenever one of the spindle-shaped aggregations of the cortical substance touches the surface of the animal, it flows in with a sudden jerk, as when one drop of fat is merged into another. This is quite decisive for the glutinous character of the material in question, and proves that a special membrane does not exist on the surface of the pseudopodia. Similar changes take place on the addition of very dilute acids and alkalies, solutions of strychnia and veratria, and under the influence of the magneto-electromotor. The influence of an elevated temperature closely resembles that of the agents just alluded to. Between 35° and 38° C. the contraction of the pseudopodia begins. The soft granular cortical substance becomes aggregated into spindle-shaped masses on the surface of the axial thread. The pseudopodia retreat altogether, and the animal might be considered dead were it not for the slow progress of a few granules in the interior, and that no haziness of the substance takes place. Schultze found *Actinophrys Eichhornii* to remain alive till 42° C.

It is remarkable with reference to Kühne's* investigations on the rigor mortis produced by heat, that even among invertebrate animals great varieties exist as to the period of its occurrence. Thus Vorticellæ begin to die at 41° C.; Difflugia, Actinophrys, and Amœba (*radiosa,* Ehrenb.), remain alive till 42° C. Anguillinæ, Turbellariæ, Naiads, Rotiferæ, and Ostracodes, are in active life at 43° C.; and a few samples even till 45° C. If we trace the pseudopodia of *Actinophrys Eichhornii* to their roots on the surface of the darker nucleus, they will be observed to lose themselves in the walls

* "Ueber die chemische Reizung d. Muskeln und Nerven," Müller's 'Archiv,' p. 315, 1860.

of the smaller alveoli. Schultze,* in his attempts to trace these radicles more accurately, encountered a number of cell-like bodies in the cortex of the nucleus. These were particularly distinct if the animal had been killed by a temperature of 42° C. A high power, then, shows that these bodies lie scattered in the cortex of the darker medullary substance. Their number may amount to forty and upwards. They are globular formations, with very delicate walls, and with coagulable, albuminous contents, and usually with numerous small, apparently homogeneous nuclei. They are in no way connected with the roots of the pseudopodia.

Such being the chief characters presented by the pseudopodia of the Rhizopods, Schultze compared them with the phenomena of motion that are to be observed in vegetable protoplasm, thus carrying out the idea of Unger, which has been already alluded to. The objects which admit of the most direct comparison with the pseudopodia of the Polythalamiæ are the threads of protoplasm that traverse the cell-cavity of Tradescantia, Viola, Cucurbita, and Hydrocaris leaf-cells. Several filaments of varying thickness pass from various parts of the protoplasm, and particularly from that portion which surrounds the nucleus, across the cell in different directions. They consist clearly of a basic substance, containing highly refracting granules. These latter run in the interior, or as on the surface of the filaments, either only in one direction, or in both, on one and the same thread. On the broadest filaments this double direction of the stream is almost constantly seen, and it may even be noticed in threads that are only just perceptible. When granules meet they may either pass each other, or the one may carry the other off—a proof that two separate filaments do not constitute the cause of the double direction of the stream. On the same thread a rapidly moving granule may overtake its more sluggish neighbour. The threads often bifurcate, and when a granule reaches the point of division, it may oscillate before selecting its further course. The shape and direction of the filaments are liable to constant change.

Bridges are formed and run upwards or downwards between the fibres, shorten as the latter approach, vanish as they coalesce, till a broad stream flows where previously there had been only separate filaments. Occasionally longer spindle-shaped masses pass along, with the same or a somewhat diminished velocity as the granules. The results obtained by the influence of various reagents (as distilled water, dilute acids and alkalies, the electric current, &c.) have so close an affinity to those obtained with the pseudopodia as to amount to a repetition of what has been already stated. The following experiment will show how sensitive the protoplasm is to certain reagents:—The staminal hairs of Tradescantia Virginica, just prior to complete development, contain many small starch granules in their protoplasm; these become violet blue on the addition of iodine. If, whilst the movement is active, a little extremely dilute iodine solution be added, all activity of the protoplasm will rapidly be arrested, even before the starch granules give any indication of a blue colour, or the protoplasm or cell-wall change their tint. In exposing these cells to the electrical current, it is found that about the same force of stream is requisite to arrest the movement of the granules as was noted for the pseudopodia. Curiously enough, those hair-cells through whose long axis the current was passed, died more rapidly than those whose long axis lay at right angles to it. The influence of the current on the movement of the granules was restricted to a retardation of it which precedes incipient decomposition. This must, of course, not be confounded with the changes in the arrangement of the protoplasm as described by Brücke,* when speaking of the hairs of *Urtica urens*:—"To follow the influence of the electric stream in its separate stages it is best at first to close the circuit only for one or two seconds, so that the hair only receives a short series of shocks. The earliest change which is then observed generally consists in the appearance of a greater or less mass of threads which project from the body of the cell into the intracellular fluid. . . . Occasionally they shoot forth like rockets from the body of the cell, as soon as the circuit of the magneto-electromoter is closed . . . At their extremity they often bear a greater or smaller intumescence, and they are engaged in a constant tremulous or oscillating movement of varying intensity."

Both Heidenheim and Schultze have seen the threads of Tradescantia become varicose under the influence of the electric current. A temperature of 30°—40° C. increased the rapidity of the granular movement, and it was found that the velocity of that in the pseudopodia of the Miliolides precisely coincided with the highest obtained from the protoplasm of vegetable cells. The temperature which was fatal to Tradescantia, *Urtica urens* and *Vallisneria spiralis,* proved to be 48° C. Already at 38° C., however, the movements began to slacken.

The difficulty of bringing the movements of the granules

* "Das Verhalten d. sogenannten Protoplasmaströme in der Brennhaaren von Urtica Urens," etc., 'Kais. Akad. d. Wiss.,' Bd. xlvi, June 20, 1862.

into harmony with those of other contractile bodies is obviously very great. The former is evidently associated with a change of locality, not only of the granules but of their immediate neighbourhood, for it is only possible thus to interpret the arrival of the substance of the pseudopodia at places that it did not previously occupy, and the complex changes in the arrangement of the protoplasma. This Brücke also admits for the hairs of *Urtica urens*, but he distinguishes two kinds of movement in their protoplasm; a slow, creeping or drawing movement, upon which the changes in the arrangement of the protoplasm depend, and a more rapid flowing which is observed in the movements of the numerous granules. Whilst the former is directly referable to contraction of the protoplasm, the latter depends upon a granular fluid enclosed by the contractile plasma, and from which it derives its movement. Thus, Brücke would draw a distinction between the cortical and medullary portion of the protoplasma. As the movement of the granules can be accounted for in the same manner as those of the pseudopodia of the Polythalamiæ, Schultze sees no reason for admitting this differentiation.

Before closing this analysis we would make a few remarks upon the fresh light thrown by these observations on the movement of granules generally. Beale* describes the mucus-corpuscles as "composed of soft semi-transparent matter which exhibits delicate spherical particles, varying in size in every part. These particles are in constant motion. In a few moments an oscillation of the particles is observed at some portion of the circumference of the mass. Then one or more bulgings occur, and parts of the surface become quite uneven by the formation of a number of little processes which move *from* the general mass and often assume the form of little spherules, which still remain attached by narrow pedicles to the general mass. Occasionally two or more processes coalesce, and a ring may be momentarily produced at some part of the circumference. From the first protrusions smaller protrusions very often occur, and these gradually become spherical, but remain attached by a narrow stem, and in a few seconds, perhaps, again become absorbed into the general mass." The different forms assumed by the same mucus particle during one minute are represented in Pl. IX, fig. 15, in Vol. XI of the 'Transactions of the Microscopical Society.' Beale further states that the transparent moving matter is itself composed of very minute, spherical particles, and describes the movements of the larger spherical particles which make their way from the general mass into the new

* 'British Medical Journal,' Nos. 115—117, 1863.

processes or bulgings that are formed. The phenomena described in the mucus-corpuscle and young epithelial cells closely resemble those observed in the pseudopodia of the Polythalamiæ. The active movements of the molecules contained in the salivary corpuscles, the various shapes assumed by these corpuscles, either spontaneously or under the influence of various reagents, and particularly the fact that magnetism is capable of arresting all this activity, have been fully described by Brücke.* The same author also describes the molecular movements of the white blood-corpuscles and of pus: "The granules which they extended evinced for a considerable time the same movements as the granules of the salivary corpuscles."

One very important question to which these observations gives rise relates to their bearing on the cell theory. It is evident that no proper membrane invests either the pseudopodia of the Polythalamiæ, or the salivary or mucus-corpuscles. Brücke† denies a membrane to the white blood-corpuscles and to pus, and has contested every argument that has been adduced in favour of its existence in the red blood disc. Beale takes the same view. Dr. Dalton has also contested the existence of this membrane. Brettauer and Steinach‡ have shown that membrane does not invest the whole of a particle of cylindrical epithelium, but only casts a conical mantle about the same. Dr. Beale§ has insisted upon the difficulties attending the acceptance of a proper membrane for the hepatic, renal, and other cells, and further states, that as in Guinea-pig's blood, each single corpuscle becomes one tetrahedral crystal, it is impossible that there can be a proper membrane to the red blood disc. He also very truly remarks that in young cells generally no cell-wall whatever exists; it is, therefore, impossible to regard the cell-wall as an essential structure. Thus grave doubts are thrown on the propriety of including the investing membrane in the definition of a cell. Schultze || does not hesitate to define the cell as a mass of protoplasm enclosing a nucleus, and he regards the formation of a chemically differentiated membrane on the surface as a retrogression.

Beale has considerably extended this definition, and in-

* "Die Elementar-organismen," 'Kais. Akad. d. Wiss.,' Bd. xliv, Oct., 1861.

† Ibid.

‡ Brücke, ibid.

§ 'On the Structure and Growth of the Tissues,' a Course of Lectures delivered at the Royal College of Physicians, 1861.

|| "Ueber Muskelpörperchen," Reichert u. Du Bois Raymond's 'Archiv,' 1861.

cludes, under the term "formed material," not only all membranes and intercellular substance, but also those various precipitates, as starch, oil, &c., that may come to occupy the interior of the cell. His "germinal matter" seems to correspond generally with Schultze's definition of protoplasm. It is the sole seat of those movements that have been described. Both Schultze and Brücke are much troubled how to regard either the origin or the function of the nucleus. The latter even says* "the constancy of its appearance is subject to essential limitations if, as cannot be avoided, the cells of Cryptogams are also considered, and it be not assumed that the nucleus must be present even where it is invisible." Schultze, on the other hand, includes the nucleus in his definition of a cell. Neither tells us in what light to regard the nucleolus when it exists, and we often find, particularly in the vegetable kingdom, that the protoplasm itself would admit a further separation of parts. If we understand Beale aright, the difference between nucleolus, nucleus, and protoplasm, is only one of degree, the former being younger and more "vitally" active "germinal matter" than the latter, but all presenting this important contrast to all formed material, that under the influence of an appropriate pabulum, they are capable of indefinite multiplication. Beale therefore regards all living structures as consisting of matter in two essentially different states, that which *is living* and that which *has lived*, and the first passes into the last, the transition being sometimes so gradual that, by the action of carmine, many zones may be demonstrated, the outer not being coloured at all, while the inner ones are very intensely coloured.† That in order to find the most active centres we must even look for particles, far smaller than the nucleolus, is most probable. It is as difficult to conceive an ultimate living centre as to conceive the universality of space. The formed material, on the other hand, whether in the shape of cell-membrane or intercellular substance, is practically but the altered germinal matter, and although endowed with most important functions, restricts the growth of the germinal matter within certain limits, and it cannot, like germinal matter, produce new matter like itself. All pabulum must pass through the formed material before it can reach the germinal matter within, and therefore it follows that the rate of growth of the germinal matter is determined by the permeability of the formed material. He thus explains alterations in the rate of growth

* "Die Elementar-organismen,' op. cit.

† 'The Structure of the Tissues;' see also a paper in the 'Archives of Medicine,' vol. ii.

without employing the doctrine of irritation. Instead of saying that the activity of a living structure is increased by an "*irritant*" or "*excitant*," he would say simply that the living matter grows faster, because the access of pabulum to it is facilitated, in consequence of rupture of the formed material which surrounds it, or by this formed material being rendered more permeable to nutrient fluids.*

The more active the growth of a tissue the smaller is the amount of formed material it contains. If we look to the cells of the yelk-bag, we find every grade of germinal matter, nucleolus, nucleus, protoplasm, varying in consistence at different depths, but we have no proof that these are surrounded by any proper membrane whatever. The protoplasm is held together by its own consistence, and the appearance of "cells" or separate masses is due to its having travelled outwards, or to its tendency to divide and subdivide.

We will, in conclusion, endeavour in a few words to show still more distinctly the difference between the views brought forward in this paper and those of Dr. Beale. This observer insists † that physical and chemical changes take place in "*formed material*," but that vital actions occur in the "*germinal matter*" alone. All that is necessary to his "cell" is —(1) matter that is *active and living*, or "germinal matter;" and (2) matter that is *formed and has lived*, but is now passive, "formed material." Neither "nucleolus," "nucleus," "cell-wall," "cell-contents," are essentials. The "protoplasm" in the Rhizopoda, &c., according to Beale, consists of particles of *living, active, germinal* matter, imbedded in *inactive* formed material, which was itself once germinal matter. In using the term "vital action," Beale admits the existence of a force or *power peculiar to living beings*. He would refer the movements of protoplasm to the vital power of the living particles entering into its composition. In all forms of germinal matter, Beale finds particles so minute that they are only just visible under a power of 3000 diameters, and he believes that living particles exist which are too minute to be seen by any power yet made. Beale therefore refers the movements seen in protoplasm to the living particles themselves, and *not to a fluid or basic matter in which they are suspended;* the latter, which usually exists in inappreciable quantity, exhibits motion, but its movements are secondary, and the impulse is communicated to it from the living particles.

* See a paper in the 'Lancet,' April, 1863.

† See papers read before the British Association for the Advancement of Science, 1861 and 1862; also 'Archives of Medicine,' vols. ii and iii.

Beale maintains that the germinal matter in every cell possesses the power of active movement; and in individual masses this movement takes place in a direction *from* centres. To it all processes of cell multiplication are referred. Beale considers that each spherical particle of living or germinal matter is itself composed of smaller spherules. In any spherule new centres of growth may arise. A piece of germinal matter may be detached from the parent mass, the "nucleus" remaining behind intact, but a *new* nucleus may arise *as a new centre in the detached portion,* and a nucleolus may arise in the nucleus, and so on. *Formation* is, according to this observer, the *conversion* of germinal matter into formed material, in which process the matter loses its *vital power,* but acquires new properties and a definite composition. Formed matter was once germinal matter, and this was once pabulum. The pabulum having become "living matter," moves outwards, as spherical particles, from the centre where the change occurred, like the particles of living matter which existed before. What appears to be a fluid, exhibiting certain streams or currents, really consists, according to him, of a number of minute spherical particles of *living matter,* every one of which possesses the power of movement. These living particles can be seen very readily with the 25th of Messrs. Powell and Lealand in the Vallisneria and Tradescantia. The larger bodies, consisting of formed material, such as starch-granules, chlorophyl, &c., are forced on in the currents produced by the movements occurring in the particles of living or germinal matter. All movements observed in "*germinal matter*" are regarded by Beale as dependent upon the peculiar "*vital*" *endowments* of the ultimate living particles of which it is composed.

TRANSLATIONS.

On the genus Lucernaria, O. F. Müller.*
(Pl. XII.)

The genus *Lucernaria,* which flourishes more peculiarly in the northern seas where it is represented by several species, has hitherto received less attention from zoologists than it has from systematic writers, and notwithstanding the various places it has occupied in systems of classification.

Recently it appeared to have found a resting place among the polyps, but at present it has been compelled to abandon this for one among the Acalephæ. As regards the anatomy of these curious creatures, we possess no important information beyond that furnished in the admirable description by Sars,† the figures by Milne-Edwards,‡ and the comparison between their structure and that of the Anthozoa drawn by Frey and Leuckart.§

As the genus had for a long time greatly excited my interest, from its constituting a distinctly transitional form between the Anthozoa and Acalephæ, I gladly seized the opportunity of studying its anatomical structure afforded me at St. Vaast-la-Hogue, not far from Cherbourg, where I obtained two species, viz., *L. octoradiata,* Lam., and *L. campanulata,* Lamx., which were abundant on *Zostera* thrown up on the rocky shore from the deeper water.

In the following pages I propose to consider, first, the structure of *Lucernaria,* and afterwards, its systematic position.

§ 1.—*The Structure.*

In this section I shall first describe Lucernaria generally;

* "Untersuchungen über niedere Seethiere." Von Wilhelm Keferstein, M.D. ('Zeitsch. f. wiss. Zool.,' xii, p. 1, 1862.)

† 'Fauna littor. Norvegiæ,' 1tes Heft, 1846.

‡ Cuvier, 'Règne animal. Zoophytes,' pl. lxiii, fig. 1, 1849.

§ 'Beiträge z. Kenntn. wirbell. Thiere,' 1847.

and afterwards, in due order, the Bell, the Stem, the Tentacles, the marginal Papillæ, the Stomach, the Gastro-vascular system, and, lastly, the Generative organs.

1. *General description.*—A *Lucernaria* (Pl. XII) may be compared in form to a goblet or a funnel with double walls; at the commencement of the stem the inner wall (s) is attached to the outer at four points or angles, so that between these points four passages into the cavity between the walls originate, the stem itself being prolonged only from the outer wall. At the bottom of the funnel, where the inner wall begins to divide at the four points, is a cylindrical elevation—the mouth (*o*) resembling the short clapper of a bell turned upwards, and which fills in this manner the narrow part of the funnel, and usually hides from view the four angles and passages into the inner cavity.

In order to form a general idea of the structure, it will be useful here to compare the different parts of the animal with those of other well-known forms, and thus to abandon any objective description, and to include in the structural details some insight into the nature of the various parts.

Sars, and Frey and Leuckart have remarked that the body of a *Lucernaria* may be compared to the disc of a Medusa. Four thin partition-walls (*r*), which spring from the before-mentioned points of the inner wall, divide the cavity between the two walls into four compartments, which communicate with one another round the margin of the cup (*r′*). The body of the *Lucernaria* so far corresponds with the disc of a *Medusa*, which presents four large radial vessels (which, in that case, may be better termed gastric pouches) and an annular vessel coursing round the margin. These gastric pouches open into a wide aperture *between the points* (above mentioned) *of the inner wall into the cavity of the stomach*, and it is clear that whilst the outer wall (*g*) of the body of a *Lucernaria* corresponds to the gelatinous disc of the Medusa, the inner wall (s) represents its natatory organ. In *Lucernaria*, where the radial vessels are so disproportionately large, the natatory organ is connected to the gelatinous disc only in four narrow tracts, while in the Medusa the reverse is the case, and the radial vessels run between the natatory organ and the gelatinous disc in the form of slender channels.

Bearing in mind that the development of the Medusæ originates in a bud formed by the intro- and extroversions of two formative membranes, we shall readily perceive that *Lucernaria* represents an aborted Medusa. In the Medusa-bud the radial vessels are not at first separated from each other, but the embryonic vascular system exists, it may be said, in the form of a subdivided conical or hemispherical space between the natatory organ and disc; the natatory and gelatinous portions of the umbrella afterwards grow together along four radial tracts, so that four wide pouches are formed, constituting the vascular system, and which communicate with each other only at the border. Now, in *Lucernaria* the gastro-vascular system remains in this condition, whilst in the Medusa it is more and more defined as the connection between the natatory and gelatinous portions of the disc becomes more and more intimate and extensive, until at last they are separate only along the lines of the slender radial vessels and in the annular vessel, which latter, however, frequently disappears also.

But notwithstanding that we are thus compelled to regard *Lucernaria* as an aborted Medusa remaining in the condition of a bud, still we cannot concur in the opinion, lately expressed by Agassiz, that *Lucernaria* resembles most the *strobila* form of *Medusa;* for the *scyphistoma,* and afterwards the *strobila,* represents a polyp in which the development has been arrested at a much lower stage than it is in *Lucernaria,* since in these forms no distinct natatory sac exists, and, consequently, also, no rudiments of a vascular system are apparent.

The resemblance of *Lucernaria* to an undeveloped Medusa is also very plainly shown besides in the mode of formation of the gastro-vascular system, in the position of the marginal tenticles, and of the reproductive organs. The *marginal tentacles* (*t*) spring, as do those of many Medusæ, from the edge of the disc, and are assembled into groups where the radial vessels join the circular vessel, and may be considered in both cases merely as prolongations of the gastro-vascular system. The bell is, commonly, deeply notched between the groups of tentacles, which thence appear to be placed upon arm-like prolongations of the bell; and in some species there is a *marginal papilla* (*p*) in the interbrachial space, which, from its structure, must be regarded as equivalent to a tentacle. The *generative organs* (*g*) are commonly found in *Lucernaria,* as in many Medusæ, on the wall of the radial vessels; but whilst in the latter they quite cover the slender vessel on the side of the natatory sac (of which vessel they appear to represent a nodular or elongated outgrowth), in *Lucernaria,* where the radial vessels are so exceedingly broad, they only appear as radiating, band-like thickenings of the wall of the natatory sac, which develops two such generative bands in the space of each gastric pouch.

Just as in a *Medusa*-bud, the bell of *Lucernaria* is supported by a *stem*, which, as the natatory sac does not extend into it, consists of only one of the two formative membranes, whose existence can be demonstrated throughout the Acalephæ. The *Lucernaria* attaches itself to various marine plants (in the two species examined by me this was always *Zostera*) by the cæcal end of this stem, and floats freely in the water, mostly downwards, more rarely upwards or in any other posture.

In Lucernaria, consequently, the same disposition of the organs obtains as that which is characteristic of the Medusæ; and in the following description, therefore, the same terms may be employed in speaking of the different parts as are commonly employed in the anatomy of the Medusæ.

2. *Bell.*—The bell consists of *the gelatinous disc*, constituting the outer wall of the cup, and of the *natatory sac*, which forms its inner wall.

The *gelatinous disc* (G) is covered outside by the outer formative membrane (*a*), and inside by the inner formative membrane (*i*), between which is a thick layer of gelatinous substance (*z*), which, as in the lower Medusæ and Siphonophoræ, is quite destitute of cellular elements, appearing to be constituted solely of fine, close fibrillæ, passing for the most part straight from one membrane to the other, and which may be regarded as mere thickenings in the structure of the gelatinous substance. A similar fibrillation occurs very generally in the gelatinous substance of the Medusæ and Siphonophoræ, and is also apparent in the problematical gelatinous substance in the body of the Helmichthydæ. Both membranes, as in all cases, are composed of a tissue of closely contiguous cells.

At the margin of the cup (fig. 3) the two membranes curve inwards and are continuous with the natatory sac (*s*), the intermediate gelatinous substance no longer existing between them, and the two membranes, consequently, coming into immediate contact. It is true that the two cellular membranes cannot be demonstrated throughout the whole extent of the natatory sac, which appears to consist only of a single layer of cells, supporting on its inner aspect a ciliated cuticle, but at the line of junction of the gelatinous disc with the natatory sac, as well as at the point of attachment of the generative organs and the oral tube (fig. 4), they may both be distinctly traced, and in the latter situation they are most distinctly seen to be separated again by the gelatinous substance.

At the bottom of the cup the natatory sac is divided into four regular angles or points (s), the apices of which are attached to the gelatinous disc. This attachment is continued in a line (r) almost to the margin of the goblet, and, by the four lines of connection produced in this manner between the gelatinous disc and the natatory sac, the internal cavity is divided into four spaces (R)—radial vessels—which only communicate with each other round the margin of the cup. These bands of connection are much broader in *L. octoradiata* than in *L. campanulata*, being in the latter almost linear, while they may rather be termed bands in the former. They always run opposite the sides of the more or less quadrangular oral tube, and at the point of each angle of the swimming sac, they meet the strap-shaped generative organs. In those species, also, in which the disc is divided into four arms, as in *L. quadricornis*, these lines of connection lie in the middle of each arm, and, consequently, if the groups of tentacles placed within the space of one expanded radial canal are to be regarded as belonging to one and the same set, in the case of these four armed cups, the two groups at the extremity of each arm do not belong to the same set, but are constituted of contiguous groups belonging to two distinct arms.

The connection of the gelatinous disc with the natatory sac, and the lines of junction of the two, may be most easily seen in a transverse section, made either in a radial direction through both walls (fig.3), or in a circular one around the cup (fig. 2).

In the outer membrane of the gelatinous disc, as well as in that of the natatory sac, numerous thread-cells are lodged, which, as is always the case, are produced in the cells of the membrane. On the outer surface of the disc they form spots of about 0·1—0·2 mm. in diameter, in which the outer membrane is somewhat tuberculated, and contains the oval thread-cells (0·011 mm. long), which are arranged side by side, like palisades, together with yellowish pigment-granules, which give a reddish colour to the whole surface.

These coloured collections of thread-cells do not often occur on the surface of the natatory sac, but in this situation they are lodged in great numbers in follicles of the outer membrane (fig. 14). These form the round, white, or, in *L. campanulata*, often turquoise-blue spots (n), visible to the naked eye, and already mentioned by Lamoureux, and which abound especially round the margin of the cup and along the course of the generative organs. These follicles are simple depressions of the outer membrane, 0·18 — 0·22 mm. in diameter, which consequently project into the internal cavity—the radial canals—and their orifice (x) is surrounded, on the exterior, by a thickened border, and has scarcely any visible canal.

The thread-cells are formed in the parietal cells of these follicles, and falling then into the cavity, which they quite fill, they can be squeezed out of the mouth. These follicles have thus, in all respects, the typical structure of a gland, and on that account claim a special interest.

The thread-cells in these receptacles, like those in the yellow spots on the outside of the *Lucernaria*, where similar receptacles are of but very rare occurrence, are of an oval form, and 0·011 mm. long; when shot out, the apparently spiral thread is seen to be placed upon a hollow peduncle, 0·01 mm. long, and furnished on the exterior with reflexed setæ. The capsule is then only 0·008 mm. long, and almost globular (fig. 15).

3. *Stem.*—The bell narrows suddenly into the cylindrical stem, the end of which is closed and expanded in a disc-like manner to form the usual adhesive organ of the animal, and which serves the same purpose as the foot of the *Actinia*.

The stem is a direct continuation of the gelatinous disc, for as the natatory sac is divided into four points at the bottom of the cup, and is also at these points attached to the disc, the stem contains no continuation of that organ, and its wall, like that of the disc, consists of the outer and inner formative membrane and the intermediate gelatinous substance.

In a transverse section of the stem, which can easily be made in *L. campanulata*, in which it contains no muscles, and is scarcely at all contractile (figs. 10, 11), the wall is seen to project on the interior into four longitudinal ridges, which are so placed as to meet above the angles of the natatory sac, as has been described by most writers. On the under side of the foot they present the appearance of four spots, and in the lower part of the stem of *L. octoradiata*—in which, however, on account of its great contractility, I have never been able to obtain a satisfactory view—they appear to be so much developed as to meet and join in the axis, so as to subdivide the simple cavity into four tubes, separated from one another, but communicating above (fig. 13, h).

In the centre of the under side of the foot there is a depression, which appears to have been first described by Lamarck as a cæcal pit (figs. 11, 12, k), projecting into the gelatinous substance. In *L. campanulata*, where the stem is non-contractile, these relations can be easily studied. In a foot-disc 0·44 mm. in diameter this pit was 0·074 mm.

deep, and it may with certainty be affirmed that it is only an inversion of the outer membrane, which, indeed, extends so far as to penetrate through the gelatinous substance, and to form a little projection in the bottom of the cavity of the stem, where, though not in the rest of the stem, the inner and outer membranes are in contact. Consequently, as, however, Lamarck has already justly remarked (*a, a,* o), there is, in this situation, no orifice communicating with the cavity of the body, such as exists, for instance, in Hydra.

4. *Tentacles.*—In all *Lucernariæ* the tentacles are placed in eight tufts round the margin of the bell, which is notched between them. In this way the tentacles come to be placed on arm-like projections, which in some species attain a considerable length, and give the bell the appearance of being deeply cleft. These arms are not always equidistant, for those which arise nearest to the partition between two radial canals are placed nearer to one another than those which arise in the extent of a radial canal. In this manner the arms form four regular groups, and the two arms of each of these groups, as may be easily surmised, do not belong to one radial canal, but to two contiguous ones; and the two arms which arise on the border opposite a radial canal support two of such groups. The nearer the two arms in one of these groups are approximated, the less deeply is the margin of the bell between them notched; the notch, on the other hand, being deeper in proportion to the degree of separation between the groups.

Whilst in *L. octoradiata* and *campanulata* the arms are scarcely perceptibly associated in pairs, and arise at almost regular distances apart, it is quite the reverse in *L. quadricornis,* in which we have apparently four long arms divided at the end. The tentacles (figs. 6, 7), which form a sort of rigid, divergent tuft on the extremity of the arm, are, as in all the Acalephæ, prolongations of the vascular system, and consequently are constituted of both the outer and inner membranes. This condition is easily observed in young tentacles, in which the gelatinous substance may often be seen between the two membranes. But in older ones, on the contrary, the in nermembrane is changed, towards the interior, into a dense cellular tissue, in which the central canal scarcely remains open, whilst on its outer side it is transformed into muscular fibres, which run in a longitudinal direction, and form a cylindrical layer, from which the tentacle derives its contractility.

The tentacles, of which I counted 25 to 27 in *L. octora-*

diata and *campanulata,* have capitate extremities, and in this part the central cavity is enlarged, and the outer membrane manifestly thickened. In *L. octoradiata* these heads are quite round, and have a diameter 0·15 mm. on tentacles which are about 1·5 mm. long. In *L. campanulata,* on the contrary, they are discoid, and often have an acetabular depression in the centre; their diameter reaches 0·4 mm. in tentacles of 1·6 mm. length, so that they are here proportionally of a much more considerable size than in those of the former species.

In *L. campanulata* the fine tentacles situated on the under side of an arm (figs. 4, 5) are of peculiar construction. They are, for instance, very short, and the base expands into a round, boss-like projection (*b*), 0·4 mm. in length, which is a thickening of the outer membrane, and is filled with thread-cells as fully as the button-like end itself. These five bosses are very regularly arranged; the lowest and central one is the largest, whilst the two on either side regularly diminish in size. Milne-Edwards did not recognise their place on the base of the small tentacles, and describes them as vesicles, and probably as representing organs of secretion.

The outer membrane of the button of the tentacle and of these boss-like thickenings contains a layer of dense, palisade-like, scimitar-shaped thread-cells, which in *L. campanulata* are 0·015 mm. long and 0·005 mm. wide, and between these some larger oval ones are irregularly distributed, having in the same species a length of 0·017 mm. and a width of 0·007 mm. These knobs contain, besides the thread-cells, granules of yellow pigment, which give them a yellow colour, often very bright.

The animal can exert prehensile movements with its tentacles, and *L. campanulata,* by means of its disc-like knobs, can attach itself as with suctorial acetabula.

5. *Marginal papillæ.*—In some species peculiar papillæ occur, regularly placed on the margin of the bell between the arms. These were first mentioned by O. Fabricius in his *L. auricula,* and I have examined them myself in *L. octoradiata,* in which species they have been described by all earlier observers.

These papillæ (fig. 1 and 3, *p*) consist of protrusions of the two membranes with the intermediate gelatinous substance, and in essential structure resemble the tentacles. They are not placed precisely on the margin of the bell, but rather under it, so that they appear like protrusions of the gelatinous disc. They have a large internal cavity, which communicates by a wide opening with the vascular system and they have usually a round or oval form. Now and then they assume quite a tentacular form, and then have a projection (p') at the end, which is filled with thread-cells, and they may be so elongated as to present exactly the aspect of isolated tentacles.

I have never found muscular fibres in the *papillæ* as in the tentacles; the muscular fibres of the margin of the bell (m'') reach to them without entering into them, but the papillæ are in spite of this very contractile, and act like extremely strong acetabula. When the foot is loosened from its point of attachment, the *Lucernaria* can still hold itself fast by these acetabular papillæ, till it has again found a secure resting-place, and individuals are often met with adhering to Zostera-stems by both the foot and marginal papillæ, especially when in danger of being torn away by the force of the ebbing tide.

The marginal papillæ are wanting in *L. campanulata*, but the knobs of the tentacles are in this case acetabular, and can be employed in a similar manner for the purposes of adhesion and fixation.

6. *Stomach.*—At the bottom of the bell (fig. 4) the natatory sac (S), as has been already described, is divided into four triangular points (s), and which are attached by their extremities to the gelatinous disc. In this way four interspaces (e), which may be compared to bow windows, are formed in the natatory sac, and which lead from the cavity of the stomach into the radial canals. Above the situation where the natatory sac is subdivided into the four points is an annular thickening or elevation, which constitutes the prismatic oral tube (o), and which, as in *Medusæ*, is probably a process of the natatory sac. A large quantity of gelatinous substance is developed between its two membranes, and its free margin is divided into four lobes, answering to its four sides, though these are often indistinct; and again, in most cases, subdivided into numerous minute lobules, and corrugated.

In the stomach we have consequently to consider, first, the true gastric cavity which lies between the four points of the swimming sac, and terminates below at the commencement of the stem, at the point where the inner wall of that part is thickened into a circular ridge, by which its cavity appears, in most cases, to be separated from that of the stomach; and secondly, the oral tube, which is very movable, and can be entirely folded upon itself. Lamouroux describes some solid discoid bodies in the wall of this oral tube in *L. campanulata*, which serve for the crushing of the food, but I have not been able to find these myself.

In this stomach the digestion of the nutriment, consisting, as all observers agree, of small crustaceæ and molluscs, is effected. I have never noticed any trace of food in the stem, or radial canals, although Sars has found some in the latter situation.

Numerous vermiform internal oral tentacles are set in a row on the margins of each point of the natatory sac, and which commonly project into the cavity of the stomach, where they move about in a serpentine manner. In the *Medusæ* these internal oral tentacles are very large, and one cannot help ascribing to them some function in the digestive process. It can be demonstrated with certainty in *Lucernaria*, as Fritz Müller has already described in *Medusæ*, that these tentacles are solid within, and consist of the gelatinous substance, covered by the outer formative membrane, and we cannot, therefore, agree with Gegenbaur, who, in *Medusæ*, nor with Frey and Leuckart, who say that in *Lucernaria* these tentacles are hollow. Many oval thread-cells are imbedded in this membrane, and it is everywhere furnished with cilia, which exist also throughout the whole gastric cavity.

These internal oral tentacles have a peculiar structure in *L. campanulata* (figs. 16, 17), the outer membrane being much thickened throughout two thirds of the circumference, and forming nodular projections on the internal aspect. This larger portion of the tentacles contains no thread-cells, which occur only in the narrow tracts, where the outer membrane is of its usual thickness, and has a smooth surface towards the interior.

7. *The gastro-vascular system.*—As parts of the gastro-vascular system in *Lucernaria* must be reckoned the cavity of the stem, and that between the gelatinous disc and the natatory sac in the sides of the bell. I cannot positively assert whether these cavities are shut off from that of the stomach at the time of digestion, but it seems, nevertheless, very probable, and when food is found in them it may be assumed to have entered there by accident.

The whole gastro-vascular system is clothed inside with delicate cilia (fig. 9), springing from the cuticle by which the cellular layer of the inner membrane is covered.

The cavity between the double walls of the bell is divided by the four lines of connection between the outer and inner membranes (*r*) into four spaces (R) answering to the four radial canals which communicate with each other at the border of the bell, up to which the lines of connection do not quite reach, and thus leave, as it were, an annular passage. In *L. octoradiata* these lines of connection are very regularly arranged. They always extend from the middle of one of the sides to the oral tube, in the direction of the longitudinal ridges of the stem, and the openings which represent the annular vessel are but small; in *L. campanulata*, on the contrary, where the lines of connection can scarcely be detected from the outside, though their existence can be proved by the introduction of a probe, they are often not absolutely radial in direction, and the annular vessel is of considerable and irregular width. When the arms of the bell are united into four groups, a similar line of connection always divides one of these groups or arms of the first order into two secondary arms, as I have already noticed. Frey and Leuckart describe eight such pouch-like radial canals in *L. quadricornis*, but Milne-Edwards has already remarked that this must be a mistake, as in that species, as well as in all the others hitherto examined, only four partition-walls and radial canals exist.

In the gastro-vascular system I have constantly found a clear granular fluid, which is kept in motion by the cilia, and the cavity is very much crowded in places by the before-described nematophorous follicles, the muscles, and the generative organs.

8. *Muscular system.*—The very distinctly marked muscular system in Lucernaria is easily recognised; it is composed of bundles of fibres running in definite directions, beyond which I have remarked no further structure.

In the stem of *L. octoradiata* (fig. 13) there are found in the above-described longitudinal ridges (*l*), but lying free in the gelatinous substance, four cylindrical or flat bundles of muscular fibres (*m*), which arise below from the pedal disc, and suddenly terminate at the apices of the four points of the natatory sac. It is to these muscles that is due the great contractility of the stem in this species. In *L. campanulata* these muscles are entirely wanting; and in accordance with this the stem exhibits very little or no contractile power, so that sections in any direction can as easily be made in it as in the stalk of a plant.

Two sets of muscular fibres can be distinguished in the bell, a *radial* and a *circular*, but these belong, as in all Medusæ, to the natatory sac alone.

The radial muscular bands (*m'*) are eight in number, one running in the centre of each arm. At the apex of each point of the natatory sac, therefore, two of these cords meet, run close to its border, and proceed quite to the end of the arms, where they become somewhat broader, and perhaps pass partially into the muscular system of the tentacles. These muscular bands are placed on the surface of the natatory sac, looking towards the cavity, and form ridge-like thickenings, upon which the generative organs are developed.

The *circular muscular bands* (*m''*) on the margin of the natatory sac are limited entirely to the border, where it turns outwards, to become continuous with the gelatinous disc. They extend from one arm to another, terminating at the summits, and perhaps giving off some fibres to the tentacles, the muscular system of which has been already described. The marginal papillæ arise in close contiguity with this set of circumferential muscles, but they receive no fibres from it, notwithstanding which, however, as before said, they are highly contractile.

9. *The generative organs.*—The sexes in *Lucernaria*, as in all the Medusæ,* are separate, and the generative organs are placed in the course of the radial canal, as in the whole family of the Thaumantiadæ. In the wall of each of the wide radial canals are two ridges, projecting into the cavity and running entirely across it. These ridges extend from the end of the arms, into which the margin of the bell is divided, to the angles of the natatory sac. Their position cannot better be described than by saying that they run on or near the above-described radial muscular bands.

These ridge-like generative organs are very apparent, and both O. Fabricius as well as Lamouroux describe them as intestinal tubes radiating from the stomach; F. Rathke was the first to suggest that they were generative organs.

More accurately considered, the generative ridges in *L. octoradiata* consist of contiguous spherical processes of the internal membrane of the natatory sac, within which (probably from a growth of the outer formative membrane, as in the *Medusæ* and *Siphonophoræ*) the generative products are developed. Whilst in the *Medusæ* these processes or thickenings of the walls of the radial canal project externally, in *Lucernaria* they are placed on the inner aspect. The inner membrane, where it covers the generative organs, especially in the female, contains much brown pigment, and by this, as well as by the whitish colour of the testicular follicles when mature, the female can easily be distinguished from

* As an exception to this, *vid.* Strethill Wright, 'On Hermaphrodite Reproduction in *Chrysaora hyoscella*," in 'Ann. Nat. Hist.,' vii (1861), p. 357.

the male, even by the naked eye. The ovisacs are densely filled with ova, of about 0·037 mm. in size; the yolk is reddish and coarsely granular, and often completely conceals the germinal vesicle and germinal spot, which are respectively 0·015 mm. and 0·004 mm. in size. The spermatic tubes have, when immature, a tuberculated aspect, from the large granular sperm-cells with which they are filled; when the product is mature, the tube presents a perfectly smooth appearance, and it then contains innumerable highly mobile spermatozoa (fig. 18), which survive a long time in water, and have a nail-like head, 0·004—0·005 mm. in length, to the broader end of which is attached the long, thick, and rigid caudal portion.

Among the numerous specimens of *L. octoradiata* which I have examined, there were as many male as female, which could not be distinguished by their form or size, but were readily detected by the colour of the generative organs, as before mentioned. Out of about twenty specimens collected of *L. campanulata* there were no females, all being males.

In the latter species the generative organs differ, in some respects, in their appearance from those of *L. octoradiata*. The spermatic tubes (which alone, from the circumstance above related, I was able to examine) form, not spherical, but merely lobular projections, and whilst in *L. octoradiata* in the middle portion of the sexual organ there are always two spherical sacs lying close together, this is not the case in *L. campanulata*, in which the entire organ appears to be constituted of a single ligulate, lobed cord.

I had no opportunity of observing either the fertilisation or development, although the specimens *lived for a week* in my glasses.

§ 2.—*On the Systematic Place of Lucernaria.*

In this section I will first trace the genus *Lucernaria* through the classifications of various systematists, and then endeavour to determine under which order of animals it may be most correctly placed; and lastly, give a synopsis of all the species at present known.

1. *Historical review.*—The genus *Lucernaria* was discovered and established by Otto Fr. Müller, and about the same time it was met with in Greenland by O. Fabricius. This Greenland species was also first published by O. Müller, though he did not recognise its affinity with his new genus, but placed it, though somewhat doubtingly indeed, amongst the *Holothuriæ;* Milne-Edwards is therefore incorrect in

citing Fabricius as the author of the genus. Fabricius himself afterwards described his Greenland species accurately under the generic name given to it by his friend, and Gmelin placed the new and very anomalous-looking genus with the Actiniæ, Holothuriæ, Medusæ, and Asteroidæ, under the Linnean order Vermes: Mollusca.

For a long time the new genus could find no systematic place, until, owing to the increased knowledge acquired of the zoophytic division of animals, fresh points of comparison for this remarkable form were perceived. Even at this early period we meet with the two views, which have prevailed up to the present day, respecting the position of *Lucernaria;* according to one—that of Lamarck—the genus belongs to the Medusoid class, whilst according to the other, adopted by Cuvier, it was deemed to be more appropriately placed near the Actiniæ.

Lamarck placed the genus with the Siphonophoræ and Ctenophora, in his division of "radiaires molasses" that is to say, of anormal Radiata, though recognising, nevertheless, its affinity with the "radiares médusaires," a view in which F. Dujardin, in the second edition of Lamarck's work, is disposed strongly to agree, although he leaves the genus in the place assigned to it by Lamarck.

In opposition to his great colleague at the Jardin des Plantes, Cuvier held that the genus *Lucernaria* must be approximated to the *Actiniæ,* as Lamouroux had before said, and formed out of it, together with *Actinia* and *Zoanthus,* his first order, *Acalèphes fixes,* in the class Acalephæ. Latreille was of the same opinion, and established an order of Radiata —the Helianthoidea—of equivalent value to the Acalephæ and polypes, and including *Lucernaria* and *Actinia*.

The systematic place indicated by Cuvier met with universal assent; and by nearly all writers, as Schweigger, Blainville, Ehrenberg, Johnston, Van der Hoeven, Dana, Troschel, Burmeister, &c., *Lucernaria* was considered to be closely allied to *Actinia,* and both genera share the same fate in further systematic arrangements, although some writers, as Ehrenberg, Allman, Van der Hoeven, and Burmeister, recognising its relations to the *Medusæ,* have doubted the correctness of placing it amongst the Actiniæ.

Lucernaria was first removed from its place near Actiniæ when its structure became better known through the researches of Sars, Frey and Leuckart, and Milne-Edwards, and Leuckart placed it among the polypes, in a second order—the Calycozoa, of equal value to the Anthozoa.

It would seem that Milne-Edwards and Jules Haime, quite independently of Leuckart, decided upon separating *Lucernaria* entirely from the Actiniæ, and divided their sub-class Corallaria into three orders—Zoantharia, Alcyonaria, and Podactinaria, the last consisting only of the genus *Lucernaria.* Milne-Edwards afterwards, came still nearer to Leuckart's view, when he admitted only two sub-classes—"*Cnidaires*" and "*Podactinaires*"—into his class Corallia, and, as unhesitatingly as Leuckart, regarded the single genus *Lucernaria* as equivalent to the whole of the Anthozoa.

As Cuvier's views at first had gained general acceptance, so those of Leuckart and Milne-Edwards were now adopted by several authors, as Troschel, Bronn, &c., who recognised the genus *Lucernaria* as the type of a distinct division among the polyps, whilst Gegenbaur, strangely enough, placed it in the order Octactiniæ, in which, however, no previous systematist had ventured to put it.

Having thus pointed out the two places occupied in succession by *Lucernaria* in systematic works, in one of which we find it associated with Actinia, and in the other to constitute a division of the Corallidæ, we come to the third and last phase in its systematic fate, in which we are carried back almost to Lamarck's view, and brought to recognise its affinity with the Medusidæ.

Lucernaria owes its new position to Huxley, by whom the entire division of the Medusidæ is denominated Lucernaridæ; in this view he is fully supported by Reay Greene and Allman, the latter recognising in *Lucernaria* a still closer affinity with the naked-eyed than with the covered-eyed Medusæ. Agassiz also places *Lucernaria* in a similar place among the hydroid polypes, and remarks upon its similarity more especially with a young Medusa; but in my opinion he goes too far, when he compares it most nearly to the *Strobila*-form. This opinion with respect to the position of *Lucernaria* with respect to the Medusæ has hitherto met with little assent, and in no systematic work has this much-vexed genus been placed in this, as it appears to me, true place. Schlegel, in his 'Manual of Zoology,' approaches nearest to its proper position in placing *Lucernaria* amongst the hydroid polypes.

2. *Systematic place.*—From the description above given of the structure of *Lucernaria*, it has been made clear how, in all essential parts, this apparently so abnormal a genus corresponds with the Medusæ, and that a correct notion of its form and the disposition of its organs may be arrived at when it is regarded as a fixed and pedunculate Medusa-bud, in which the stomach has been formed, and is open at the end,

but in which the radial canals still retain a very great width, and are separated from each other only by narrow dissepiments; which bud remains in this stage of development, reaches maturity, and develops sexual organs along the course of the radial canals.

With respect to its Medusoid resemblance, I could here only repeat what has been laid down in many places in the former sections, and will merely add that, in the points where *Lucernaria* approaches the Medusæ, it differs in the essential parts from the Actinioid animals. In it, for instance, we do find neither the stomach hanging in the visceral cavity, nor the reproductive organs seated on the free margins of the septa, both points characteristic of the Anthozoa. Nor have I been able to discern anything in its structure decidedly polypoid, as stated by Leuckart, who, according to his as yet unpublished researches, expresses a decided opinion in favour of the affinity between his Calycozoa and the polyps.

The class Cœlenterata, which has everywhere met with the warmest acceptation, and against which Agassiz alone has expressly declared himself, I would subdivide, as has also been done by Leuckart and others, into three sub-classes—*Anthozoa*, *Ctenophora*, and *Acalephæ*.

These three divisions may be distinguished by the structure of the stomach; in Anthozoa it is suspended freely in the cavity of the body, which is divided into chambers by radial septa; in the Ctenophora, in which the construction of the stomach bears most resemblance to that of the Anthozoa, a canal system always exists, which conveys the products of digestion throughout the body, and in Acalephæ the stomach either hangs freely down or is excavated in the substance of the body itself. The Ctenophora, which are usually, since Escholtz, placed amongst the Acalephæ, are so essentially separated from them by the microscopical structure of their parts, and have so much resemblance to the Anthozoa, that it is more proper to consider them as a group of the Cœlenterata, equivalent to the Acalephæ and Anthozoa.

Under the Acalephæ I arrange, in the first place, the *Medusæ*, with the hydroid polyps which have been properly grouped together as Hydrasmedusæ; and, as a second order, the Siphonophoræ. To the Hydrasmedusæ, at first sight, belong very different creatures:—1, minute polyps, which split up into Medusæ by the transverse division of their upper part; 2, large polypidoms, some of which throw off Medusa-like buds, while the propagation of others is carried on by ova; and 3 and lastly, *Medusæ*, which have almost always originated as buds on polypes, though they are frequently also developed directly from ova. All these forms, however, are closely allied, as the numerous transitions between them show; and however great may be the importance set by nature in the higher animals, on the processes of reproduction and development, this seems to be by no means the case in the order of creatures we are considering; and however regularly the different stages of *ovum, polyp,* and *Medusa,* may, in one form, be gone through, in another this regularity is entirely wanting, and the animal often remains at the polyp stage, and whilst in it becomes capable of reproduction; often also it entirely omits the polyp stage, and emerges at once from the ovum in the form of a Medusa. But all these diversities, as has been said, afford no ground for systematic divisions, and since we find the Medusoid generation to be subdivided into two forms, which were distinguished as far back as by Escholtz, and have been named by Gegenbaur, the Acraspeda and Craspedota, so also can the Hydrasmedusæ in the same manner be divided into suborders, to which the Lucernariadæ are to be associated as a third.

When we thus assign *Lucernaria* as a sub-order to the order of the multiform Hydrasmedusæ, all that is extraordinary in its structure by degrees disappears. Since in this order we find numerous Medusæ originating immediately from the *ovum,* and others which first bud out into a polypidom, it is readily conceivable that there may also exist forms exactly as in *Lucernaria,* in which the *Medusa* remains at the commencement of its development, but is capable, in this conditiou, of reaching sexual maturity.

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3. *The genus Lucernaria and its species.*—Having thus considered the structure and systematic position of *Lucernaria,* we may define the genus as follows:

Lucernaria, O. F. Müller, 1776.

An animal presenting the general structure of a Medusa, having the form of a pedunculated bell. The peduncle dilated at the base into a discoid expansion, by which the animal attaches itself. The margin of the bell produced into eight more or less projecting arms, furnished with numerous tentacles, and which arms are often arranged in four pairs. Four wide radial canals, separated only by thin dissepiments, and communicating with each other at the border of the bell. Mouth elongated into a quadrilateral oral tube. Internal tentacles in the stomach. Sexual organs situated in eight tracts in the walls of the natatory sac, corresponding to the eight arms.

The genus is probably confined to the northern seas; and in Europe the Channel, and in America Fundy Bay, appear to be its southern limit. Quoy and Gaimard, it is true, mention it as occurring at Toulon, but very vaguely, and later observers have never met with *Lucernaria* in the Mediterranean.

The species of the genus have hitherto remained in considerable confusion, arising chiefly from the circumstance that that first observed by O. Fabricius has been regarded as identical with the one since described by J. Rathke under the same name. But this is now well known not to be the case, as I have satisfied myself, and as had previously been stated by Steenstrup and Sars.

1. *Lucernaria quadricornis.*
   L. quadricornis, O. F. Müller; Gmelin; Lamouroux; Sars; v. *Carus,* Milne-Edwards.
   L. fascicularis, Fleming; Lamouroux; Ehrenb.; Johnston; Frey and Leuckart.

Char. Bell depressed, shorter than the stem. The elongated arms united into pairs, separated only at their extremities, and each furnished with numerous (about 100) tentacles. Reaches 70 mm. in size.

Hab. This, which is the largest of the known species, occurs throughout the coasts of Norway, in the Cattegat and Sound, also in North and South Greenland; on the east coast of North America; Faroe and Shetland Islands.

Sars once noticed, among numerous specimens of *L. quadricornis,* one with a marginal papilla between the four arms; whether this may prove a new species, Dr. Keferstein does not venture to decide.

2. *L. auricula,* O. Fabricius.
   L. auricula, Gmelin; Sars; Steenstrup.

Bell deep, infundibuliform, subcylindrical, with eight small, equidistant arms, between which are eight very minute marginal papillæ. Stem as long as or longer than the bell. Length 40 mm.

This species has till quite recently been confounded with others. Lamarck, Blainville, and Sars place it with *L. quadricornis,* whilst J. Rathke, Montagu, Johnston, and Milne-Edwards associate it with *L. octoradiata.*

Its distinction was first recognised by Steenstrup, and afterwards by Sars.

Hab. Coasts of Norway; Greenland; Britain, &c.

3. *L. octoradiata,* Lamarck.
   L. octoradiata, Lamarck; Steenstrup; Sars.
   L. auricula, J. Rathke; Montagu; Sars; Johnston; Milne-Edwards.

Bell rather deeply infundibuliform, with eight short, equidistant arms. Eight large marginal papillæ between the arms. Stem equal in length to the depth of the bell. Length 30 mm.

This species has hitherto been confounded with *L. auricula,* O. Fabric.; for although Lamarck, who gave it the name of *octoradiata,* regarded *L. auricula,* Fabr., as synonymous with *L. quadricornis,* Müll., subsequent writers considered his *L. octoradiata* as a synonym of *L. auricula,* Fabr. Steenstrup was the first to clear away this great confusion.

Hab. Norway; British Channel, both sides; Holland; South Greenland, and the Faroe Islands.

4. *L. campanulata,* Lamouroux.
   L. auricula, Montagu; Milne-Edwards.
   L. campanulata, Lamouroux; Johnston; Milne-Edwards.
   L. octoradiata, Lamarck.
   L. convolvulus, Johnston.
   L. inauriculata, Owen.
   ,, Jules Haimes.

Bell rather deep, infundibuliform, with eight equidistant, long arms. Stem scarcely as long as the bell is high, and not containing any muscles. Length 45 mm.

Hab. Shores of the British Channel and south of England, to which it appears to be confined.

This species, though accurately described by Lamouroux, has been often confounded with *L. octoradiata.*

5. *L. cyathiformis,* Sars.
   L. cyathiformis, Sars.
   Depastrum cyathiforme, Gosse.
   Carduella cyathiformis, Allman.
   Calcinaria cyathiformis, Milne-Edwards.

Bell cup-shaped, expanded at the margin. Border circular, not divided into eight arms, furnished throughout with tentacles, which are, however, assembled into eight equidistant groups. Stem equal in length to the height of the bell. Sexual organs arranged together in pairs, not reaching to the border of the cup. Length 15 mm.

From this species, which was originally described by Sars, have been made the genera *Depastrum*, Gosse, *Carduella*, Allman, and *Calcinaria*, Milne-Edwards, but it is here left under *Lucernaria*, where it was originally placed by Sars, as Dr. Keferstein is unable to find any essential distinction between it and the other species of the genus.

Hab. The coasts of Norway and England.

Closely allied to it is the following species:

6. *L. stellifrons*, Gosse (sp.).
   Depastrum stellifrons, Gosse; Allman.
   ,, *cyathiforme*, Gosse.

Bell cyathiform, constricted below the opening. Border octangular; arms 0, but the tentacles are placed in eight equidistant groups, between the angles of the border. Sexual organs reaching the border. Stem as long as the bell. Length a few millimètres.

This species was found by Gosse on the English coast, but he confounded it with *L. cyathiformis*, and formed out of the two his genus *Depastrum*. Soon afterwards, however, he distinguished it from *L. cyathiformis*, and named the new species *D. stellifrons*. By Allman it was regarded as so distinct as to induce him to make it the type of the genus *Depastrum*, in contradistinction to *Carduella*, for which he took *L. cyathiformis* as the type.

Remarks.

1. It may be mentioned that Professor Reay Greene is inclined to unite *L. quadricornis*, *octoradiata*, and *campanulata*, with a single species, which he names *L. typica*, stating that he has met with an intermediate form connecting these three species. But it appears to the author, as it does to Leuckart, to be not improbable that this intermediate form is *L. auricula*, Fabr., which is readily and essentially distinguishable from the others, with respect to whose independence the author agrees with Leuckart and Percival Wright in considering that there can be no doubt.

2. Although Fabricius, under the name of *Lucernaria*

phrygia, describes an animal which, according to his description, has little similarity with *Lucernaria*, and of which he himself remarks—"De hujus genere etiamnum dubitans, pro tempore Lucernariis associavi, in multis tamen hydris affinem," but which, nevertheless, has been included in many works under Lucernaria. Blainville, it is true, remarks that it cannot belong to the genus *Lucernaria*, but adding that it cannot even be placed under the type of his Actinozoa. He consequently makes of it a distinct genus, *Candelabrum*, which he places among the Sipunculidæ.

Steenstrup, who, as has been stated, first made out from the manuscripts of O. Fabricius his *L. auricula*, has at last pointed out the true place of *L. phrygia*. According to him, it is a colony of hydroid polypes, most nearly resembling the genus *Acaulis* of Stimpson.

Researches *on the* Nature *of the* Vorticella-stem. By Elias Mecznikow.*

The question respecting the anatomical and chemical structure of the lowest organisms possesses at the present time a special interest from its relation to the discussions regarding the cell-theory, which have of late been carried on so warmly. In order to throw some light upon this question, the author, under the guidance of Professor Sczelkow, undertook a series of researches respecting the behaviour of some of the Infusoria towards various physical and chemical reagents. These researches, however, being incomplete, he has in the present paper confined himself to a portion of them to which he had devoted more particular attention, viz., on the stem of *Vorticella*.

With regard to the nature of this organ, two principal views have been for a long time entertained. According to one of these, first enunciated by Ehrenberg,† the central streak in *Vorticella* is a muscle. Dujardin,‡ on the other hand, denied the muscular nature of this part. Both views have found advocates. In favour of the former of them, we have Eckhardt, Czermak, Leydig, Claparède, Lachmann, and Kühne. Eckhardt§ confirms Ehrenberg's view, and, more-

* 'Archiv. Anat.,' 1863, p. 180.
† 'Die Infusionsthierchen,' &c., 1838, pp. 274, 279.
‡ 'Hist. Nat. des Infusoires,' 1841, pp. 49, 50, and 547.
§ 'Archiv f. Naturgeschicte, 1846, i, pp. 217, 218.

over, points out a special connection between the shortening and extension of the stem and the motions of the ciliary apparatus, which is retracted on the shortening, and protruded on the extension of the stem. Czermak* showed that the streak itself was spiral, and that the shortening, of the stem was effected by it. Leydig † even describes transverse lines on the central streak of the *Vorticellæ*—an appearance which is regarded by him as a strong proof against the theory of unicellular organisms. Claparède and Lachmann‡ fully agree with Czermak, and assert, besides, that the central streak when retracted is lost sight of in the hinder part of the body.

Among the opponents of this view may be named Dujardin, Ecker, and Stein. The first thinks that the movements of the stem do not depend upon the enclosed band, but upon the external membrane; but this was completely and correctly disproved by Eckhardt. Ecker thus expresses himself respecting the nature of the stem: "The contractile substance of the body is continued into the stem, the form of which part it consequently follows, but this band-like portion is nevertheless not a muscle." Stein,§ however, is the most determined opponent of Ehrenberg's view. This observer denies the existence of transverse lines on the central band, which were first described by Gleichen and afterwards by Ehrenberg. Besides this, Stein subjected the *Vorticellæ* to the action of various substances, and found that the central band exhibited the same reactions towards them as the internal parenchyma of the body itself; he thence concludes that the stem is not identical with muscular tissue.

This was the state of the question before the publication of Kühne's || researches, by which this author was led to the same conclusion as Ehrenberg and his followers. Kühne compared the effects of various physical and chemical reagents on the muscles of the frog and on the stem of *Vorticellæ*, and found them to be essentially the same in both cases.

The author having instituted some researches according to Kühne's method, is desirous of communicating them, inasmuch as the results at which he has arrived differ widely from those of Kühne.

1. *Electricity.*—The phenomena observed were as follows:

* 'Zeitsch. f. wiss. Zool.,' iv, p. 438.

† 'Lehrb. d. Histologie,' 1857, p. 133.

‡ 'Zeitsch. f. wiss. Zool.,' i, p. 236 (note).

§ 'Die Infusionsthiere,' 1854, pp. 78—80; and 'Der Organismus der Infusionsthiere,' 1859, p. 54.

|| 'Myologische Untersuchungen,' 1860, p. 213—222.

A weak induction-current has no effect on the Vorticellæ;* but when the force of the current is increased up to a certain point, its passage through the preparation caused the instantaneous contraction of all the stems; but even when the current was maintained for some time, this position was not long retained. The animalcule soon stretched itself out again, and began its movements afresh. The force of the current may now be increased considerably without any change in the phenomena. But if a very powerful current is applied, the Vorticellæ, it is true, roll themselves up, but they die almost immediately, as is shown by the circumstance that on the breaking of the current the animalcules remain perfectly still; and if the same strong current is kept up for any length of time, the Vorticellæ break up, as Kühne very truly states. It is to be remarked, moreover, that whilst under the influence of the galvanic current, the anterior ciliary apparatus always remains retracted, as stated by Kühne.

2. *Rhodankalium*, a substance which, as is well known, produces powerful contractions and sudden rigidity in muscle, does not, from what the author has observed, even in a tolerably concentrated solution (0·3 grm. to 5 cc. water), produce any effect whatever on the movement of the stem of Vorticella; nor are weaker solutions (0·3 grm. Rhodankalim to 10, 15, 20 cub. cent. water) any more efficacious. It is certainly very interesting to observe the length of time the Vorticellæ can live in these solutions, since all other Infusoria observed by the author, even the lowest (*Monas*), die very speedily in them. But the Vorticellæ, even after their body has become quite deformed and angular by the action of the solution, nevertheless still continue to move. This observation was several times repeated by the author, and always with the same result, although it is in direct contradiction to Kühne's assertion, that the stem of Vorticellæ contracts and becomes rigid in a solution of Rhodankalium.

3. *Veratrine.*—It is usually stated that Veratrine is insoluble in either cold or hot water, but this is not correct. The author boiled, five times in succession, the same quantity of Veratrine in distilled water, and the filtrate on each occasion assumed a carmine-red colour on the addition of concentrated sulphuric acid.

It is well known that Veratrine is a very powerful muscular poison, inducing very speedy contractions and rigidity. A

* The species employed in all the experiments were *V. convallaria*, Ehr., and *V. microstoma*.

frog, into which a filtered, very bitter decoction of Veratrine had been injected, soon died. Nothing of the kind takes place when Infusoria are exposed to the same solution, and numerous experiments have satisfied the author that this poisonous agent has no effect whatever upon the life of Infusoria. The stem of Vorticellæ moves just as actively in a solution of Veratrine as before its immersion, and the whole behaviour of the animal presents nothing abnormal. Kühne describes the action of this poison quite otherwise. He states that the *Vorticellæ* are killed by it, and that the stem contracts and becomes rigid—statements which the author has been wholly unable to confirm.

4. *Hydrochloric acid.*—According to Kühne, a solution of this acid containing $\frac{1}{1000}$th part induces speedy contractions and rigidity in the stem, succeeded by its solution. But this statement the author is not able to confirm any more than he is the preceding. In his experiments he employed a solution of the same strength as that used by Kühne, and observed the following results:—At first the stem is moved with some rapidity; but the movement gradually becomes slower and slower, and at last ceases altogether. The same phenomena are manifested also when much stronger solutions are employed (3 drops in 5—10 cub. cent. of water).

5. *Common salt.*—Concentrated solutions of this salt immediately kill all Infusoria; weaker ones act less energetically, the Infusoria dying more slowly. A solution containing half part of salt per cent. had no effect whatever upon the stem.

6. *Chromic acid.*—According to Kühne, this acid causes muscle to contract. In the stem of Vorticellæ, a solution containing two parts in the hundred causes sudden contraction, and extension never again takes place, although the body of the Vorticella continues to live. This contraction, however, cannot be attributed to the property possessed by chromic acid of coagulating albumen, since other substances possessing the same property (alcohol, acetate of lead) have not the same effect.

7. *Bile.*—The sudden application of bile kills and dissolves all Infusoria; whilst a slower one allows them to die more slowly. But bile has no irritant effect upon the stem of Vorticella, although in the frog's muscle its application is followed by contraction and shrivelling up.* Diluted bile has no effect whatever on the movements of the stem.

8. *Sulphate of copper.*—Solutions of this salt of any strength cause the most powerful contraction in muscle; but in the stem of Vorticellæ even concentrated solutions have no effect.

* Kühne, op. cit., p. 24.

The stem, in fact, even when the body of the Vorticella is wholly contracted and wrinkled, still exhibits movements.

9. *Caustic potass.*—The sudden application of a solution of potass containing not more than one part in a hundred instantly kills all Infusoria; its more gradual application is followed by less rapid decease. It has no effect whatever on the stem of Vorticella, although in muscle it produces contractions.

10. *Curara.*—With respect to this substance the author fully confirms, from long-continued observation of his own, Kühne's statement that it has no effect on the stem of Vorticellæ. This fact appears the more interesting when we find that the poison is not without influence upon the body of the animal, as may be seen in the circumstance that the anterior ciliary apparatus always remains retracted under it.

When the action of the various reagents employed by the author is considered, it must be allowed, he says, that, at any rate, we have no right at once to identify the mobile element in the Vorticella-stem with a muscle, as many have done; and this view is the further supported by the fact that the stem presents no property of double refraction in polarized light, as repeated observations have shown. He, moreover, takes the opportunity of remarking that he was as unable as was Kühne to confirm Leydig's statement respecting the transverse striation of the stem. "When it is examined," he says, "with a power of 1000 diameters (Ocular No. 4, and system No. 9, à immersion, of Hartnack) no doubt can be entertained as to its homogeneity and as to the non-existence of transverse striation."

REVIEWS.

Popular Physiology.—1. *A Manual of Animal Physiology, for the use of Non-medical Students.* By John Shea, M.D. London: Churchill.—2. *A Manual of Popular Physiology; being an attempt to explain the Science of Life in Intellectual Language.* By Henry Lawson, M.D. London: Hardwicke.

The publication of two manuals almost simultaneously, devoted to the subject of physiology and for the instruction of unprofessional persons, is certainly a subject for congratulation. Of all the departments of human knowledge which the recent progress of natural science has systematised and made available for the practical use of mankind, physiology is undoubtedly the most important. It deals with the facts and laws of life—than a knowledge of which there is nothing more important to man. Just as he has gained a knowledge of the conditions that influence his life, has he become more civilised, more healthy, more moral, and more religious. In utter ignorance of the laws of life no man can live. The facts with which he becomes instinctively acquainted serve him, in his barbarous and civilised state, to maintain his existence and even increase his race; but it is in those conditions of society where men are taught those laws of life which are the result of sufficient investigation, that we can alone anticipate the healthiest existence and the highest moral and religious development. It has been only within the present century that physiology, by embracing the statistics of life and death in large communities of men, and tracing minutely, with the aid of the microscope, the minute details of the changes which go on in the system to produce these grand results, has been in a position to claim the attention of man. It now comes forth with an authority which ought to compel its principles to be listened to and its precepts to be taught to all who have an interest in health and life. We would here especially suggest to those who are engaged in microscopic investigations into the nature of those changes which go on in the tissues of the body, that they should make the knowledge they thus gain as practical as possible. Let them not be satisfied with the beauty or the interest of minute vital changes, but let them strive to connect them with the great laws of life by which the population of the world is maintained and human health and happiness secured. Microscopical research is not an end, and the microscope is only an instrument to help the eye to investigate the more minute phenomena of matter, in whatever form it presents itself. Of all the practical directions in which a fondness for microscopic research may be made available for the benefit of the individual who makes it, and for the circle in which he moves, is that of striving to understand the laws which regulate the healthful existence of his own body. The man who acquires any kind of knowledge at the expense of health has made a poor exchange, and the highest use to which human knowledge can be applied is to gain good health and length of days. As introductions to a knowledge of the great laws of life which are already known, we can recommend the manuals named above They differ in matter and style, but they have the same object in view. Dr. Shea's is a plain, straightforward account of the phenomena of life, and is the result of much reading and reflection; Dr. Lawson is much more discursive, does not hesitate to introduce his own views of phenomena, and endeavours to amuse whilst he instructs. If we were asked for what class of readers they are adapted, we should say that Dr. Shea's manual was best adapted for a class, whilst Dr. Lawson's would be found more available for private reading and self-instruction. We will, however, endeavour to give our readers an idea of these useful little books by extracts from those portions of the books which treat of microscopical subjects. We first give an extract from Dr. Shea's account of the blood.

"BLOOD-CORPUSCLES.—Two varieties of corpuscles exist, red and white. As seen under the microscope, they are flattened cells, of a circular form, the red presenting either a bright or dark central spot, as they are brought in and out of focus.

"*Red corpuscles* are present in large numbers in the blood; their diameter varies from $\frac{1}{3000}$th to $\frac{1}{4000}$th of an inch, and their thickness is about $\frac{1}{10000}$th of an inch. When examined singly they appear almost colourless, and it is only when viewed in numbers that they exhibit the florid colour.

"*White corpuscles* are much less numerous than the red, not more than one white to fifty coloured being present in human blood. As a rule, their diameter is greater than that of the red corpuscles, and may be estimated at $\frac{1}{2300}$th of an inch. The form and appearance of the corpuscles, both red and white, varies greatly, according to the character of the liquid in which they float. The colour of the blood may even be altered by a change of form in the corpuscles. Thus it is probable that the difference in colour of arterial and venous blood depends on an altered form of the corpuscles contained. When subject to the action of water, corpuscles swell, become convex, or even round, and may at length burst.

"With regard to the structure of *red* blood-corpuscles, they may be considered to be cells, provided with an elastic cell-wall, enclosing apparently homogeneous contents impregnated with red colouring matter, called hæmatine. The *white* corpuscles, however, seem to contain granular matter, the cell-wall being scarcely ever visible unless the corpuscles are treated with water or diluted acid, when the cell becomes distended, and the wall separated from the enclosed matter.

"If the minute vessels in the web of a frog's foot are examined, both varieties of blood-corpuscles will be seen hurrying along in the current of the blood, the red moving rapidly in the centre of the stream, the white passing more slowly along the sides of the vessels.

"The functions served by the blood-cells have not been determined, nor has it been ascertained how or where they are formed. The most probable source of their origin is, that they are formed from the chyle and lymph corpuscles poured into the blood from the *thoracic duct;* as in the general current of the blood, corpuscles in intermediate stages of development are always found, and indeed, occasionally the fluid in the thoracic duct has a red tinge, supposed to be due to the commencing development of hæmatine in the interior of the chyle-corpuscles. Doubtless the blood-cells are continually undergoing decay, whilst others are being generated to supply their place; and most likely they are derived in the manner just noticed, for they are proved not to be developed by fission of the pre-existing corpuscles.

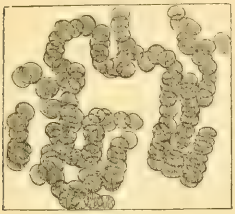
"Chemically, the blood may be regarded as an alkaline fluid, composed principally of water, containing a certain amount of solid matter. Amongst the more important components of the solid matter, hæmatine may be mentioned. It is stated to contain iron, and is found mixed with globuline, the compound being termed *cruor*.

Chemical Composition of the Blood.

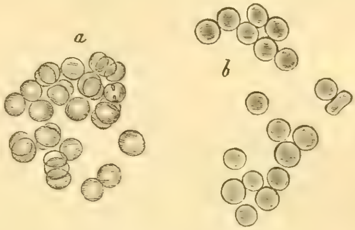
Blood	Water			795
	Solid matter	Corpuscles	Hæmatine	8
			Globuline	140
			Iron	1
		Fibrine		2
		Albumen		40
		Fat		2
		Salts		8
		Extractive matter		4
				1000

"The difference between venous and arterial blood, as regards colour, has been already noticed; but other differences exist; thus, in the arterial fluid there is less albumen and more fibrine than in the venous. Moreover, the specific gravity is lower, the amount of red corpuscles greater, and probably, the proportion of oxygen larger in the arterial blood.

"*The quantity of blood in the body.*—The precise determination of this point is difficult. It has been found that if numerous vessels in the body of an animal are opened, and the blood permitted to pour from them, a



Piles or rouleaus of red corpuscles, exhibiting a peculiar tendency that these corpuscles possess of running together and adhering by their broad surfaces.



Blood-corpuscles: *a* and *b*, the two different appearances of red corpuscles.

large quantity can be collected. In this manner it has been estimated that the weight of the blood is to that of the body:

As 1 to 12 in an ox.
„ 1 to 18 in a horse.
„ 1 to 16 in a dog.

These data can only be an approximation to the truth; for however freely the vessels are opened and the blood permitted to flow, still a large quantity must remain in the body. Nor can such an experiment be made on the human subject, except, indeed, in cases of execution. It is stated that as much as 24 lbs. of blood were taken from a decapitated female. Applying the results of experiments on other animals to the human body, it appears that the amount of blood contained may be estimated at 18 lbs. to 20 lbs."

We now give an extract from Dr. Lawson's account of the cilia:

"The larger bronchial tubes are lined on the inside by a beautiful delicate down, soft as velvet, of which I have just placed a portion under the microscope; and what a pretty sight is presented—a field of corn in miniature! This down is formed by an almost infinite number of extremely minute, hair-like filaments, resting on club-shaped projections,

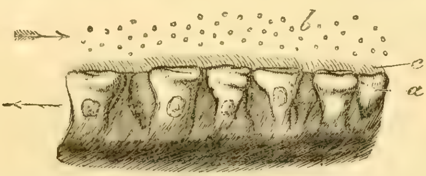


Fig. 40.—A portion of the lining membrane of the Windpipe, showing the Cilia. *a*, the club-shaped cells; *b*, particles of matter; *c*, the Cilia.—The arrows indicate the direction of the currents.

and perpetually moving in one direction, giving exactly that appearance to the eye which is produced by a meadow swayed in gentle undulating curves by the action of the wind (*vide* fig. 40). I now drop a small quantity of a solution of potash upon the specimen, and I have a "dissolving view" produced, for the elegant little filaments (cilia) have vanished.

Surely, these exquisite organisms are not without a purpose! There must be some office which they fulfil.

> "Oh, happy living things! No tongue
> Their beauty might declare:
> A spring of love gushed from my heart,
> And I blessed them unaware."

The cilia always move in *one* direction, and in the bronchial tubes this is toward the windpipe—upwards. Hence all particles of dust, all sorts of materials in a finely powdered state, which may be accidentally sucked in during respiration, are prevented descending into and accumulating in the air-cells by the influence of these cilia. A small, almost atomic, portion of road dust we often draw into the lungs on a blustry summer's day, but it effects no injury, for it hardly has got in before the cilia "take it in hand," and it is sent back again from one to the other till it has reached the mouth.

"Were it not for this grand provision, all the millers and stonecutters would be exterminated in a very short period. Even as it is, they do meet their death sooner than other folk, because of the inability of the cilia to prevent all the particles entering. A more energetic atom than usual will elude their vigilance and slip down occasionally, and this being oft repeated, the collected matter sets inflammation and other morbid processes agoing, which end in the extinction of life. The bronchial tubes and windpipe are composed of a kind of gristle or cartilage, mixed with tissue of sinewy description; and in addition to these there are a few fibres of muscular tissue (flesh). These muscular filaments can hardly be seen, but a very ingenious experiment has shown us their existence. Muscle always contracts when galvanized, and therefore if a galvanic shock causes the lung tissue to contract, it probably contains muscle. An English physiologist having dissected out the lung and bronchial tubes of an animal, placed the entire organ so that the opening of the windpipe was opposite the flame of a candle; next he applied the wires of the galvanic battery to the lung, and he heard the air rush out, and saw the candle extinguished."

With these extracts we must conclude our notice of these manuals, commending them to the notice of all who are anxious to acquire or spread a knowledge of the first principles of physiology.

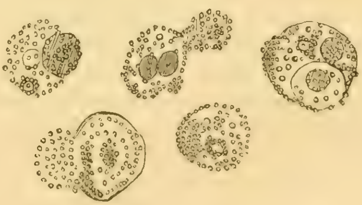
Three Lectures on the Formation of Mucus and Pus, being the Lumleian Lectures of the Royal College of Physicians. By Dr. T. K. Chambers.

The Lumleian lectures have this year been delivered by Dr. Chambers, the subject chosen being the formation of mucus and pus. The use of the microscope is of course essential in researches such as those which Dr. Chambers details, and we therefore give a brief abstract of the lectures taken from the report of our contemporary, the *Lancet*. "A physiological fellow of our college," says Dr. Chambers, "was in the habit of regarding his patients as so many 'mucous membranes.'" The term was no exaggeration, for to the medical man the mucous membrane is all-important. Most of the drugs administered to his patients act on it, and all are introduced through it. The business of mucous membrane is to offer a passage for oxygen, water, fat, albumen, and other nutrimentary substances, and to defend the less easily renewed tissues beneath it, from the deleterious action of external agents. These functions are performed best when it is bedewed with a moderate watery exhalation, and not with mucus. It must not be supposed that the secretion of mucus is the special function of a mucous membrane; in fact, the membrane is most active when there is least mucus. The secretion which usually moistens its surface, possesses nothing of that stringy adherent character by which we recognise mucus. It is transparent and watery, and contains the epithelial scales shed from the surface. Shed epithelia are found also in mucus, but not as a peculiar characteristic. Its most obvious characteristic is the presence of transparent viscid bodies of an oval form, and with one or more nuclei in their interior; the fluid in which these are placed seems to be that whence the peculiar consistence and adhesiveness of the mucus is derived. This seems to be the case, since oval globules similar to those of mucus constitute the bulk also of pus, which has entirely distinct attributes and properties. Professor Henle's view with regard to these globules seems very plausible. He considers them as young epithelia, prematurely moulted from the body. The condition which produces them is an arrest of development. The peculiar structure of epidermal tissue is well known, consisting of cells flattened externally by pressure, and rounder, looser, and more globular as they approach the inner surface. This is the structure of both the scarf-skin and mucous membrane; the former covering the whole external superficies of the body, the latter acting as a protection for the surfaces of the various internal viscera and canals. The "mucous globules," of which mention has been made, appear to be the young epithelial cells, and may be seen by removing the external layer of scales more advanced in development. They are exactly identical with the inner strata of the epidermis, the *rete mucosum* of Malpighi. Dr. Chambers gives a very minute account of the development of these epithelial cells. He says:

"The appearance they have is that of all matter when it first puts on life. The telescope and the microscope equally reveal to us these nebulæ as the earliest indication of vitality, drawing the surrounding chaos towards a central point, then exhibiting that central point as a kernel or nucleus. And then this kernel becomes the parent of new centres, individual and separate, and these again starting places of new action. The dawn of vitality is exhibited in the coalescence of molecules of organic matter so as to form nuclei, which, under favorable circumstances, develop either separate cells or tissues.

"Up to this point each focus of life seems to be a separate individual. It takes in nourishment by its innate power from without; it increases in size and alters in shape. And this alteration in shape seems principally to take place from within. It is not merely an aggregation outside of new molecules, but a plastic change of internal appearance. Nay, more—it possesses the faculty of giving birth to an individual, and so to a succession of individuals, like itself. No better evidence of automatic existence can probably be given.

"These phenomena can be seen without much difficulty in the globules of mucus. That which answers best is what we often expectorate in little semi-transparent gelatinous lumps from the bronchi in the morning after exposure to night air. This must not be mixed with water or be allowed to cool, but kept at the temperature of the body, and put immediately under a lens of as high a power as you can command. Dr. Beale showed me the phenomena first under a 24th, but I have seen them very well under an 8th inch in an old-fashioned Powel's microscope. Keep your eye fixed on one nuclear mass, and you will often see a gradual change in its appearance. First a clearer nucleus appears in it; then, as you gaze, two, three, or more smaller nuclei. Then the fine granular speck into its sides coalesce into a nucleus. Then you see that it has a bulge in its side, and that a nucleus forms a bud, and then has a constricted neck or stalk. And then, perhaps, if you are lucky enough to get the mucus in motion without losing sight of your object, the bud may float off as a separate globule. Or the whole globule may divide into two each with a separate nucleus.



"A temperature below that of the body seems to check this development, but you may often keep it on by means of a spirit-lamp. The globules in which I have seen it take place are those from the trachea, from the os uteri, and from warm freshly-passed urine in cases of inflamed bladder.

"When the fluid has got dried up by the heat thus constantly applied, you may in some degree restore its activity by moistening it with a viscid animal fluid, such as saliva. The greater part, indeed, is broken up into molecules, and these show no disposition to unite into globules, but among them will remain some globules unbroken, and these will again form new nuclei, and bud as they did at first."

"Each of the globules appears to be a centre of life, into which nourishment passes from the outside, and enables them to increase in number." "Mucus," says the lecturer, "may be regarded as a parasite, receiving from the body its nutriment indeed, but not its form nor its claim to vitality." The similar globules forming the bulk of pus are, when in freshly secreted matter of all shapes and sizes irregular, budding, with or without nuclei; but in that which has been secreted some time, the globules are nearly all of one size, even, and spherical. This seems to indicate a general change of form by time—a certain completion of creation in that which has been the longest formed. The growth of these globules is not, in Dr. Chambers' opinion, comparable with that of ordinary cells; for some of the buds spoken of are not derivatives from the central nuclei, but new starting points of growth. He, therefore, considers the globules themselves as nuclei, or rather composed of nuclear matter. Dr. Beale has shown that when tissues are steeped in a solution of carmine, the nuclei or young growing matter in them are the only parts which receive a permanent stain. Now, the entire mass of the mucous globules receives a permanent stain from carmine, and they appear, therefore, to be equivalent to the nuclear matter of ordinary cells. The question now arises as to how these mucous globules make their way to to the surface of the membrane, where they are found. They are developed beneath the epithelium, whereas, when we find them, they are quite uncovered. Dr. Buhl, of Munich, has shown that they undergo a modification, and *pass through* the epithelium. He has seen them *in transitu.* Dr. Chambers suggests that these bodies may want the solidity they appear to possess, and yet have a definite shape and form, and considers it at least an open question, whether both epithelial scales and elementary globules may not possess rather the properties we attribute to fluids. The observations of Henle, Rindfleisch, and others, Dr. Chambers remarks, "seem to show that the pus or mucus globule on mucous membranes is the material of young or renovated epithelial cells, arrested in its development at the earliest dawn of life, before it has assumed the form of a cell, when it is as unlike its destined final form as an egg is to a chicken. They seem to show that in this state it may be thrown directly off by the epithelium being broken, or it may pass into the substance of the epithelium. In either case it does not part with the low degree of life it has acquired; but neither does it acquire a higher degree; it goes on propagating, but nothing more." Buhl's observations differ from those of Rindfleisch in this particular. Buhl contends that the epithelial cells increase by simple division. Rindfleisch asserts that he has watched a process going on analogous to that of yelk division. It appears that both may be right.

In his third lecture, Dr. Chambers treats of the chemical nature of pus compared with that of mucus, and enters into some details as to the production of pus under inflammation, and the various external agents which may affect the mucous membrane. He also makes some very able remarks upon the manner in which various drugs act beneficially in certain diseases through the mucous membrane. Some of Dr. Chambers' speculations are certainly wild, and he frequently clokes a very simple and obvious fact under a multitude of words; nor have the lectures the merit of much originality, being more a summary of what has been done on the subject than anything else: but, on the whole, they are well worth the attention of physiologists and pathologists, and will prove a useful addition to the English literature of the subject.

NOTES AND CORRESPONDENCE.

Sunlight Illumination of Diatoms.—Dr. Maddox (whose skill and success in obtaining micro-photographs is well known) remarks, in a letter to me, dated 28th July, "I have seen in the photograph what I never saw in the object with the most careful illumination." Some years ago, in one of my communications to the Society, "On obtaining Photographs of Microscopic Objects," I mentioned the very peculiar distinctness with which markings on test-objects were shown on the screen, and expressed my opinion that the photographs might aid in determining their structure. Dr. Maddox's remark having revived this impression, I placed my microscope in strong sunlight—illuminated the object with the *concave* mirror and an achromatic condenser of large aperture. As a consequence, the illumination was so intense that no object could be looked at directly through the microscope, as the eye would not endure the light for an instant. To look for markings was precisely like attempting to discern spots on the sun's disc through a telescope without the protection of sun-glasses; but by taking the red and green glasses off my sextant (which, combined, gave a pleasant neutral tint to the sun), and laying them on the caps of the eye-pieces, the light was toned down to just the right pitch, and the markings on *all the most difficult tests* were easily and quickly brought out with remarkable distinctness. In objects of extreme difficulty the parabolic dispenser may be employed, directing the sunlight with the *plane* mirror. With the achromatic condenser and direct sunlight, the sap circulation in *Anacharis* is beautifully shown.

I feel that some apology is due for the smallness of this announcement, but as many who use the most costly microscopes and apparatus appear to use them principally for the purpose of displaying the markings on the most difficult tests, to these anything should be welcome that will aid in stimulating or coaxing an expression into the reluctant aspect of their favorite objects, and who can easily contrive arrangements for holding glasses of various shades and colours.

In many instances, with artificial illumination, the best effect would be obtained by throwing the most intense light possible on the object; but in this case the light fatigues the eye and destroys its sensitiveness. It is then usual either to lower the achromatic condenser, or to employ a lamp with a blue shade; but by placing a light moderator of coloured glasses over the *eye-piece*, the object may be examined with the strongest light obtainable.—F. H. Wenham.

On Coloured Illumination.—Since Mr. Wenham called my attention, a few days past, to the employment of strong sunlight passed through an achromatic condenser, behind the object, and coloured glasses over the eye-piece, in the examination of various objects, the markings of which under the ordinary method of illumination are somewhat indistinct, I have made a few trials with such colours as were to hand. They were not of a sufficiently extended character to enable me to say in what particular class of objects the method may be found most useful, therefore these remarks may prove of very little value.

The external contour of many pale objects appeared more defined; in insect structures the internal parts were more distinct, with bolder shades giving contrast relief to the other parts. It appeared requisite to seek the coloured glass most useful to appropriate, what I would call, the false light, otherwise in many objects it did not offer anything striking. The coloured glasses tried were light orange, medium or rather blue, intense green, intense neutral tint, and carbuncle red. They were variously arranged. The first two, used together, gave a very pleasant tint to the field, but I do not think they were of sufficient intensity to permit of long employment without fatigue to the eye. Many of the diatoms gave their interstructural lines very distinctly. Intense green alone had a fine effect in Aulacodiscus, Arachnoidiscus, Heliopelta, cotton-fibre of Zostera, &c. Deep neutral tint appeared useful in the examination of the paler kinds of Acari, the orange colour gave to the deeper coloured Acari a depth in their structural parts. The carbuncle red scarcely permitted any structures to be seen. The same glasses placed behind the condenser, also behind the object, were not equal in effect to when placed over the eye-piece. The neutral tint, however, seemed to throw up some structures with more definition when behind the slide. Over the prism in the camera lucida, the image of many objects appeared very strongly; the pencil indistinct. The more or less translucent structures, as the feet and claws of Acari, had considerable boldness, and the foreshortening in the claws was more marked. Possibly many of these variations may be due to the nature of the glass employed in the slide and objective, also of the medium in which the object was mounted, and might therefore relate to these as well as to the objects themselves.

Having much used sunlight concentrated by a prism and condenser in photomicrography, I consider the use of coloured glasses over the eye-piece with sunlight will render service in cases of doubtful structure. Sunlight with the parabola was employed by the Rev. Mr. Osborne in his examination of *Closterium Lunula*, 'Mic. Journ.,' No. VIII. Mr. Jabez Hogg, in the third edition of his work on the 'Use of the Microscope,' says in examining the same object: "Strong daylight should be transmitted through coloured glasses proposed by Mr. Rainey, and adapted to $\frac{1}{4}$-inch condenser, using $\frac{1}{8}$ objective." I expect an equal if not a better effect would be found by using sunlight and coloured glasses over the eye-piece, as suggested by Mr. Wenham. I was not able to successfully use the parabola for producing photograph negatives.—R. MADDOX.

Method of Dry-mounting Entomological and other Objects.—Have ready a number of rings punched from thin gutta percha, supported on lead, folded in thin paper, to prevent "jagged" edges. Place the specimen on the slide, then the ring, the specimen being in the centre; then place a round cover on the ring, taking care to centre it to the round opening. Steady the cover by means of a needle, and apply a gentle heat beneath the slide. The gutta percha will become transparent, and a gentle circular pressure applied by the needle will cause both glasses to adhere. Allow the slide to cool, and afterwards remove the superfluous gutta percha with a penknife. The edge of the cover must then be cemented with varnish, applied in very small quantity at first. A second coating will complete the preparation.—THOMAS SHARMAN RALPH, Melbourne, Australia.

PROCEEDINGS OF SOCIETIES.

Royal Society.

May 7, 1863.

On the Structure *of the so-called* Apolar, Unipolar, *and* Bipolar Nerve-cells *of the* Frog. By Lionel Beale, M.B., F.R.S., F.R.C.P., Professor of Physiology and of General and Morbid anatomy in King's College, London, and Physician to King's College Hospital.

(*Abstract.*)

The author adverts to the opinion generally received with regard to the existence of *apolar*, *unipolar*, *bipolar*, and *multipolar* nerve-cells, and observes that if cells having such very different relations to the nerve-fibres they are supposed to influence, as apolar, unipolar, and multipolar cells, do actually exist, as many different kinds of action must be admitted. For it is hardly likely that a nerve-cell unconnected with any fibre can affect the fibres at a distance from it in the same way as a cell acts upon fibres which are in structural continuity with it. Neither is it probable that a cell with but one fibre proceeding from it can constitute an organ which acts upon the same principle as the cell from which two or more fibres proceed. If no fibre, or but one fibre proceeds from certain cells, the formation of complete nervous circuits, at least in these instances, is impossible; and if it be admitted that circuits do not exist in every case, a strong argument is advanced against the existence of such complete circuits as a necessary or fundamental condition of a complete nervous apparatus. But if it can be shown, on the other hand, as the author maintains is the case, that all the supposed apolar and unipolar cells have at least two fibres proceeding from them, the fact must be accepted in

favour of the view that such complete circuits may exist, while the fact that the fibres connected with many cells have been seen to proceed in opposite directions some distance after leaving the cell, is a very strong argument in favour of such general inference, and at the same time an explanation of many arrangements which are observed constantly in connection with nerve-fibres in various tissues.

Many observers have described *apolar* and *unipolar* cells in ganglia in different parts of the frog. The author, on the other hand, has failed to discover any apolar or unipolar cells in this or in any other animal, and considers that the apparent absence of fibres, and the presence of one fibre only in connection with a cell, result from the defective modes of preparation generally employed. He maintains that every nerve-cell, *central* or *peripheral,* has at least two fibres proceeding from it.* In many cases he has demonstrated that these fibres pursue opposite directions, and he considers that such an arrangement is general, and therefore necessary. The author considers himself justified in drawing the following conclusions from observations he has made during the last three years:

1st. That in all cases nerve-fibres are in bodily connection with the cell or cells which influence them, and this from the earliest period of their formation.

2nd. That there are no apolar cells, and no unipolar cells, in any part of any nervous system.

3rd. That every nerve-cell, central or peripheral, has at least two fibres in connection with it.

Though the present inquiry is limited to the structure of the particular cells connected with the ganglia in different parts of the frog, the author has studied the arrangement of nerve-cells and nerve-fibres in nervous centres, as well as at their peripheral distribution, in many different animals.

* The word "cell" is only used in a general sense, as being shorter and more convenient than "elementary part." It consists merely of, 1st, matter in a living, active state (*germinal matter*), and 2nd, matter resulting from changes occurring in this (*formed material*). In Pl. XIII, what is ordinarily termed "nucleus" and "nucleolus" of the nerve-fibre consists of germinal or living matter, while the matter at the lower part of the cell and the nerve-fibres are formed material. A nerve-fibre cannot produce a new nerve-fibre, but the "nucleus" or germinal matter of a nerve-fibre can produce new nerve-fibre. The formed matter never produces matter like itself. Germinal matter can produce matter like itself, and from this formed material may result.

1. *General description of the ganglion-cells connected with the sympathetic and other nerves of the frog.*

The general form of these cells is oval or spherical; but the most perfectly formed ganglion-cell is more or less pear or balloon-shaped in its general outline, and by its narrow extremity is continuous with nerve-fibres which may be followed into trunks.

The figure represents a well-formed ganglion-cell from a ganglion close to one of the large lumbar nerves of the little green tree frog (*Hyla arborea*). The substance of the cell consists of a more or less granular material, which by the slow action of acetic acid becomes decomposed, oil-globules being gradually set free. Near the fundus or rounded end is seen the very large circular nucleus with its nucleolus. In some of these cells, at about the central part or a little higher, are a number of oval nuclei, some of which are in connection with fibres. The matter of which the mass of the cell consists gradually diminishes in diameter, and contracts so as to form a fibre, in which a nucleus is often seen. At the circumference of the cell, about its middle, the material seems gradually to assume the form of fibres, which contain numerous nuclei, and these pass around the first fibre in a spiral manner. Thus in the *fully formed cell a fibre comes from the centre of the cell* (*straight fibre*), *and one or more fibres* (*spiral fibres*) *proceed from its surface.* These points are represented in fig. 16, Pl. IX, Vol. XI, 'Transactions of Microscopical Society.' *

2. *On the formation of ganglion-cells in the fully formed frog.*

The subject is arranged under the three following heads, but as it would not be intelligible without figures, it will not be given in abstract. The development of these cells and many other structures may be studied in the fully formed animal as well as in the embryo.

a. Ganglion-cells developed from a nucleated granular mass like that which forms the early condition of all tissues.

b. Ganglion-cells formed by the division or splitting up of a mass like a single ganglion-cell.

c. Ganglion-cells formed by changes occurring in what appears to be the nucleus of a nerve-fibre.

* The specimen from which this drawing was taken has been seen by many observers.

3. *Further changes in the ganglion-cell after its formation.*

Under this head the movement of the cell from the point where its growth commenced is described. It is shown that the two fibres, which at first seem to come from opposite extremities of the cell, lie parallel to each other. They increase in length, and subsequently one is seen to be twisted round the other, as shown in the figure. Sometimes the fibres below the point where the spiral arrangement exists run parallel for a long distance, but at length pursue opposite directions. The author considers that the formation of the ganglion-cell commenced at the point where the fibres diverge, and that subsequently the cell moved away,—the parallel fibres, which at length become straight and spiral, being gradually formed or drawn out as it were from the cell.

4. *Of the spiral fibre of the fully formed ganglion-cell.*

The spiral fibre or fibres can be shown to be continuous with the material of which the body of the cell is composed, as well as the straight fibre, but the former are connected with its surface, while the latter proceeds from the deeper and more central part of its substance.

There are many nuclei in connection with the spiral fibre, and several nuclei of the same character imbedded in the substance of the mass of which the cell is composed. These latter nuclei seem to be connected with an earlier condition of the matter which becomes, when more condensed, spiral fibre. A great difference is observed with regard to the extent of the spiral fibre in cells of different ages. In the youngest cells the fibres near the cell are both parallel to each other, but as the cell grows one is seen to be coiled round the other; and the number of coils increase as the cell advances in age, while the matter of which the fundus of the cell is composed gradually becomes less—apparently in consequence of undergoing conversion into fibres. Nuclei are found in the course of the straight fibre, as well as in connection with the spiral fibre. Nuclei have been demonstrated in connection with the dark-bordered fibres near their origin and near their distribution in all tissues.

Next follows a discussion "on the essential nature of the changes occurring during the formation of all nerve-cells, and on the formation of spiral fibres," but this is not adapted for an abstract. The term "nucleus" is only employed in a general sense. The author believes that the "nucleus," "nucleolus," and centres within the latter ("nucleoluli") merely represent centres of different ages. He considers that the matter of the nucleus becomes gradually transformed into the formed matter around it, and generally that these bodies are merely centres which arise in pre-existing centres. He maintains that from the outer formed matter connected with the fibres new nerve-cells could not be produced, while he holds that from the nuclei, nucleoli, and contained centres, entirely new and complete cells could be evolved. So he considers that the difference in the properties and powers of the formed matter on the one hand, and the nuclei and nucleoli on the other, depends upon these two kinds of matter having arrived at different stages of existence. That which is formed cannot form new formed matter, nor appropriate nutrient material; but the living germinal matter of the nucleus can be resolved into formed matter, and it can appropriate inanimate pabulum, and confer upon it the same wonderful (vital) powers which it possesses itself, and which were communicated to it from pre-existing germinal matter.

7. *Of the fibres in the nerve-trunks continuous with the straight and spiral fibres of the ganglion-cells.*

The conclusions upon this important question are as follows:—

1st. That in some instances very fine fibres, not more than the $\frac{1}{60,000}$th of an English inch in diameter, are alone continuous with both straight and spiral fibres of the ganglion-cells.

2nd. That a dark-bordered fibre may be traced to the ganglion-cell as the *straight fibre*, while the spiral fibres are continued on as very fine fibres.

3rd. That the spiral fibres may be continued onwards as a dark-bordered fibre which may even be *wider*, at least for some distance, than the fibre continued from the straight fibre.

4th. That both straight and spiral fibres may be continuous with dark-bordered fibres.

It is therefore quite certain that the spiral fibre is not connective tissue, although the author considers it probable that many German observers may adopt this view until they have an opportunity of seeing the fibres themselves.

8. *Of the ganglion-cells of the heart.*

The author's conclusions are quite opposed to those of Kölliker, who states that all the cells are *unipolar*, and that the fibre always passes in a peripheral direction, also that the transcurrent fibres of the vagus have no connection with these cells. The author, on the contrary, affirms that the cells have at least *two fibres coming from them*, that some of the fibres pass towards the heart, and others towards the brain. He regards it as very probable that many at least of these ganglion-cells are connected with fibres of the vagus. Kölliker has also stated (1860) that many apolar cells could be seen in the heart, ganglia, and in the bladder. The author has been able to demonstrate fibres in connection with so many cells which appeared devoid of fibres, that he considers himself justified in denying the existence of apolar and unipolar cells altogether.

Next follow some observations on "the ganglion-cells and nerves of arteries;" "on the connection of the ganglion-cells with each other;" and the paper concludes with a description of the so-called "capsule" of the ganglion-cell, and a discussion on the nature and formation of the connective tissue and its corpuscles in the immediate neighbourhood of nerve-fibres.

The paper is illustrated with forty-seven drawings of the specimens, magnified from 700 to 1700 linear; and the author states that many of the specimens will probably retain the appearances he has copied for several months. All the preparations have been made in the same manner. An outline of the process has been already given in the author's previous communications, but the author is aware that it may be some time before the correctness of his conclusions is generally admitted, in consequence of the difficulty of preparing demonstrative specimens.

June 5th, 1863.

FURTHER OBSERVATIONS *in favour of the view that* NERVE-FIBRES *never end in* VOLUNTARY MUSCLE. By LIONEL S. BEALE, M.B., F.R.S., Fellow of the Royal College of Physicians, Professor of Physiology and of General and Morbid Anatomy in King's College, London; Physician to King's College Hospital, &c.

(Plate XIII.)

FEW anatomical inquiries of late years have excited more interest than the present one. Since my paper published in the 'Philosophical Transactions' for the year 1860, several memoirs have appeared in Germany. In my paper just published in the last volume of the 'Transactions,' I have replied to the statements of Kühne and Kölliker, but I had not succeeded in actually tracing the very fine nucleated fibres I had demonstrated from one undoubted nerve-trunk to another. As a *demonstration*, therefore, my conclusions *were defective*, though the only explanation to be offered of facts I had observed was that included in the view I propounded in my first paper. The question between my opponents and myself upon this matter is not one of interpretation, but a question of simple fact. I assert that the fine nerve-fibres can be followed much further than the point where Kühne and Kölliker maintain the ends or *terminations* are situated, if the specimen be so prepared as to prevent destruction of these most delicate fibres, and the refractive power of the medium be such as to enable us to see them.

I propose to present to the Royal Society next session a paper in which I shall *demonstrate* the truth of the conclusions I have arrived at; but as my specimens are already prepared, and during the last few months several drawings have been made, I hasten to give a short statement of facts, in order that those who have been led to conclusions opposed to my own may have an opportunity of studying the very same muscle.

The great width and refractive power of the large elementary fibres of the pectoral of the common frog render it impossible to follow for any great distance amongst them nerve-fibres of the $\frac{1}{60,000}$th of an inch = ·000187''' in diameter; and I have therefore long been searching for a very thin voluntary muscle, with fine fibres, which, like the bladder of the frog, could be examined without the necessity of making thin sections, and thereby deranging the relation of all the finest and most delicate structures. Such a muscle I have found in the *extensive mylo-hyoid of the little green tree-frog* (Hyla arborea.) The elementary fibres of this muscle are scarcely more than the $\frac{1}{3000}$th of an inch = ·0036‴ in diameter; and as there are but two layers, the fibres of which are at right angles to each other, all the structures in the muscle can be demonstrated most beautifully. The very long thin muscular fibres are not too close for exact observation. The vessels can be readily injected.*

These specimens have been prepared upon the same plan as others, and are preserved in glycerine, which enables me to press the thin muscle and separate the fibres further from each other, while the finest fibres of the nerves are prevented, by the viscid medium, from breaking or from being so compressed amongst the other tissues as to be destroyed or rendered invisible. The muscle must be prepared when quite fresh, otherwise the fine nucleated fibres are completely disintegrated. The capillaries were injected as in the other cases.†

In this thin muscle, networks formed by bundles of dark-bordered fibres, consisting of from two to five or six, may be very easily shown, and with high powers (700 to 3000 diameters) the very fine nucleated fibres resulting from the division and subdivision of these in a dichotomous ‡ manner, can be readily demonstrated.

In this thin muscle I have often followed individual fine nucleated nerve-fibres, now over, now under muscular fibres, sometimes crossing transversely, sometimes obliquely, and sometimes running for a certain distance parallel to the fine muscular fibre. The drawing accompanying this paper renders further description unnecessary. I shall enter into full detail in my communication next session; but as the summer

* The very thin and wide intercostal muscles of the Chameleon, after having been soaked in glycerine, may be separated into two layers, *external* and *internal intercostals*, in each of which the finest ramifications of the nerve-fibres may be followed, and their relation to the sarcolemma demonstrated. The long elementary fibres of the thin tubular part of the tongue of the same animal are also favorable for this investigation; but the Chameleon is only to be obtained occasionally, and the muscle of the green tree-frog, above referred to, possesses many advantages.

† As the details of the mode of preparing these specimens would occupy many pages, I must defer entering into this part of the question; and it is useless to give the outline, as success depends entirely on minutiæ.

‡ The dichotomous division is most common; but sometimes three, four, or even five branches result from the division of one fibre, as is well known to be the case in the common frog.

is the period to obtain specimens of the *Hyla*, I am anxious my fellow-labourers in Germany should at once be acquainted with the advantages of the thin muscle alluded to; and I cannot too strongly recommend this beautiful little frog, which they have the advantage of procuring more readily than Englishmen, for microscopical investigation. All the tissues are beautifully distinct, and I challenge those who are interested in these questions to discuss them with me, selecting the tissues of this animal for special study.

British Association for the Advancement of Science.

Newcastle was unfortunate in the choice of its time for the annual meeting of this Association. It was in the midst of the holidays, when people have chosen their tours and resting places, and cannot be disturbed. The consequence has been that, although Newcastle did its best, the outside public were fewer in number and repute than usual. We have looked over the reports of the proceedings, but cannot find any matter that would interest our readers; not that there were not subjects brought before the section that would have interested them, but that it is impossible that scientific accounts of these meetings should be published. When the 'Athenæum' employed a scientific reporter in each section, its reports were complete, and could be relied on, but now that it merely reprints the journals of the Association and copies newspaper reports, its accounts are of less value. We have often thought it would be worth while for the Council to publish an authorised report of the proceedings at the time, each section naming its own reporter and editor. The newspaper reports are admirably done, but it is too much to expect that ordinary reporters could competently supply those technical details which constitute the real value to scientific men of the contributions read at the section. Through the kindness of the author we are enabled to give the following abstract of a paper on "Life in the Atmosphere," read at the Physiological Section on Saturday, August 29th, by James Samuelson, Esq.

The author commenced by saying that no subject in natural history, excepting the allied one, the origin of species, had of late excited greater interest than the origin of the lowest types of living beings on the globe, which had led to investigation, the indirect effect of which had been to throw fresh light on the anatomy and life-history of the mysterious forms of which the subject treats. It was with the latter view, chiefly, that the author laid before the Association the results of his recent experiments on Atmospheric Micrography.

First, however, he passed briefly in review the leading facts connected with the "Spontaneous Generation" controversy, referring to the opinions held by the advocates and opponents of the doctrine.

These views have at various times been published in the 'Microscopical Journal,' and the author quoted the leading expressions of Professor Pouchet, of Rouen, Messrs. Jolly and Musset, &c., in favour of, and those of Pasteur in opposition to, the doctrine, referring his readers to the various portions of this Journal in which they appeared for a full account of the controversy. He also touched upon the experiments of Wyman, of Boston, who has recently entered the lists as the advocate of heterogenesis, and of his own, which, irrespective of those he has published, were rather adverse to the doctrine than otherwise. As our readers will think, however, Mr. Samuelson's experiments to be now described present features totally opposed to what ought to be expected if the doctrine of heterogenesis were true, for he found in distilled water, containing the dust of various countries, many of the chief infusorial animalculæ usually supposed by the advocates of "heterogenesis" to be spontaneously produced in infusions of decaying organic matters.

Let us briefly recapitulate the chief results of these experiments. In 1862, in conjunction with Dr. Balbiani, of Paris (the author of a very accurate and interesting work, recently published, 'On the Reproductive Organs of Infusoria'), he exposed certain infusions in Paris and Liverpool, and in both places and in all the infusions the same forms were found amongst dissimilar ones. Some of these were traced to the dust on the windows of the operators, and in one case Mr. Samuelson found in pure distilled water, after it had been exposed to the atmosphere for a few days, the same form (*Cercomonas acuminata*, Dujardin) as he had found in his infusions, in dust taken from the high road, and in the catalogue of infusoria forwarded by Dr. Balbiani, as having been present in *his* infusions.

Encouraged by these results, the author obtained dust by shaking rugs imported from the following countries, namely, Melbourne, Japan, Alexandria, Tunis, Trieste, and Peru, and these different kinds of dust he kept until June, 1863, and then sifted them through muslin on the surface of distilled water, each kind having, of course, its appropriate vessel of water. He also exposed pure distilled water in a three-partitioned box covered with lids of blue, red, and yellow glass.

The results of these experiments he read before the Academy of Sciences in July, and in the same month he repeated them, which were concluded just before the meeting of the Association.

The following are the results obtained from this double set of experiments:

In the case of the distilled water, exposed under coloured-glass lids (partially open), the glass intercepted the dust, and there was hardly any sign of life. When the dust was washed into the distilled water, a light deposit settled at the bottom of the vessels, and on examination under a low power the subsequent day, the author found mineral particles imbedded in a gelatinous film. (He examined the deposit without removing it from the vessel, by pouring off the water and placing the glass vessel itself under his instrument.) This film, under a higher power, was resolved into a mass of minute, fixed monads, possessing a tremulous motion. The next day a re-examination showed that these monads had become active, and peopled the water.

So much for the distilled water only. Now as regards the various kinds of dust.

In that of Egypt, Japan, Melbourne, and Trieste, life was the most abundant, and the development of the different forms was very rapid. These consisted of Protophytes, Rhizopoda, and true Infusoria.

In most of the vessels he first observed the forms known as Monads and Vibrions; and from these he traced the development, first of one, and then of another species of Infusoria. In the dust of Egypt he found a new Amœba, whose motions were very rapid, and the pseudopodia of which he compared, both as regards their shape and mode of formation, to the soap-bubbles blown by children with a pipe. He described the normal globular form of this Amœba, its gradual changes until its pseudopodia were in full action, its conjugation, and some other phenomena in its life-history.

In the same dust, and in this only, he clearly traced the development of *Protococcus viridis*, which was, at last, present in such numbers as to tinge the water green.

In Egypt, Melbourne, and Trieste, he found *Cercomonas acuminata* (Dujardin), which his colleague and he had found in the dust of Paris and Liverpool; and in Egypt he followed the development of an entirely new form, from a long "vibrion." He thus describes this new type: "It was an annulated vermiform animalcule, the ring being quite distinct, and each one furnished with cilia. The whole series of cilia extending along the body acted in concert, imparting to the animalcule a motion precisely resembling Naïs amongst fresh water, and Nereis amongst marine annelides.

Beyond the distinct flashing of the cilia (of which he could not count the number on each ring), a circlet on the anterior segment, and what appeared to be a canal running through the whole length of the body, neither organs nor members could be traced. Each ring had, however, a distinct existence, for they were cast off from time to time, and moved about freely. The animalcule grew by the subdivision of its ring, and became divided by their separation. It moved freely backwards or forwards, and often when divided into two parts, which remained attached to one another, an independent ciliary action was noticeable on each, but not such as to interfere with the movements of the whole.

He further described how its annulated structure was gradually converted to a smooth surface; and some other changes which he observed. Its length varied from $\frac{1}{150}$ to $\frac{1}{100}$ inch; and he regarded it as a larval form, or series of forms, bearing the same relation to some other (unknown) Infusorium as the Strobila larva does to some of the Medusæ.

In the dust of Japan he followed the development of a monad, first into what appeared to be a minute paramecium, then into *Loxodes cucullulus* (Dujardin), and finally into *Colpoda cucullus* (Dujardin), and his experiments are quite confirmatory of the supposition that many Infusoria now classed as distinct types are really one and the same species in different stages of development.

He also found, as stated by Dr Wallich, that certain Amœbæ (*A. radiosa*) are only another stage of others that have been described as distinct types, just as in the case of the Infusoria. Our space will not admit of our transcribing more of these experiments, the recital of which was profusely illustrated with diagrammatic plates, but we believe our readers will agree with us that they open out an entirely new field for microscopists, and deal a heavy blow at the doctrine of heterogenesis as at present understood. Mr. Samuelson's conclusions are in one sense rather amusing.

In drawing attention to the tenacity of life possessed by the germs which were revived under his eye, he says that, in *his* case, they survived the heat of a tropical sun and the warmth of his room; but in that of Dr. Pouchet (the leading partisan of spontaneous generation), who obtained his dust from the interior of the pyramids of Egypt, "they retained their life 2000 years, and then survived an oil bath of 400° of heat.

We cannot close these observations without referring to a useful practical application of these experiments, suggested by the author, and approved by the President of the Section, Professor Rolleston, and by many gentlemen who were present at the delivery of the lecture, namely—the examination of the air of hospital wards, in order to trace, if possible, the existence of germs likely to cause epidemic disease.

Mr. Samuelson claimed no originality for this suggestion, for he said that Dr. Pouchet had spoken of such an investigation, but he believed that, with the peculiar views entertained by the French naturalist, he could hardly be expected to go to his work with an unprejudiced mind, and with a chance of practical good resulting. He, therefore, recommended our hospital surgeons to make the test. In this view Professor Rolleston quite concurred, and several valuable hints were thrown out as to the best means of conducting the investigation.

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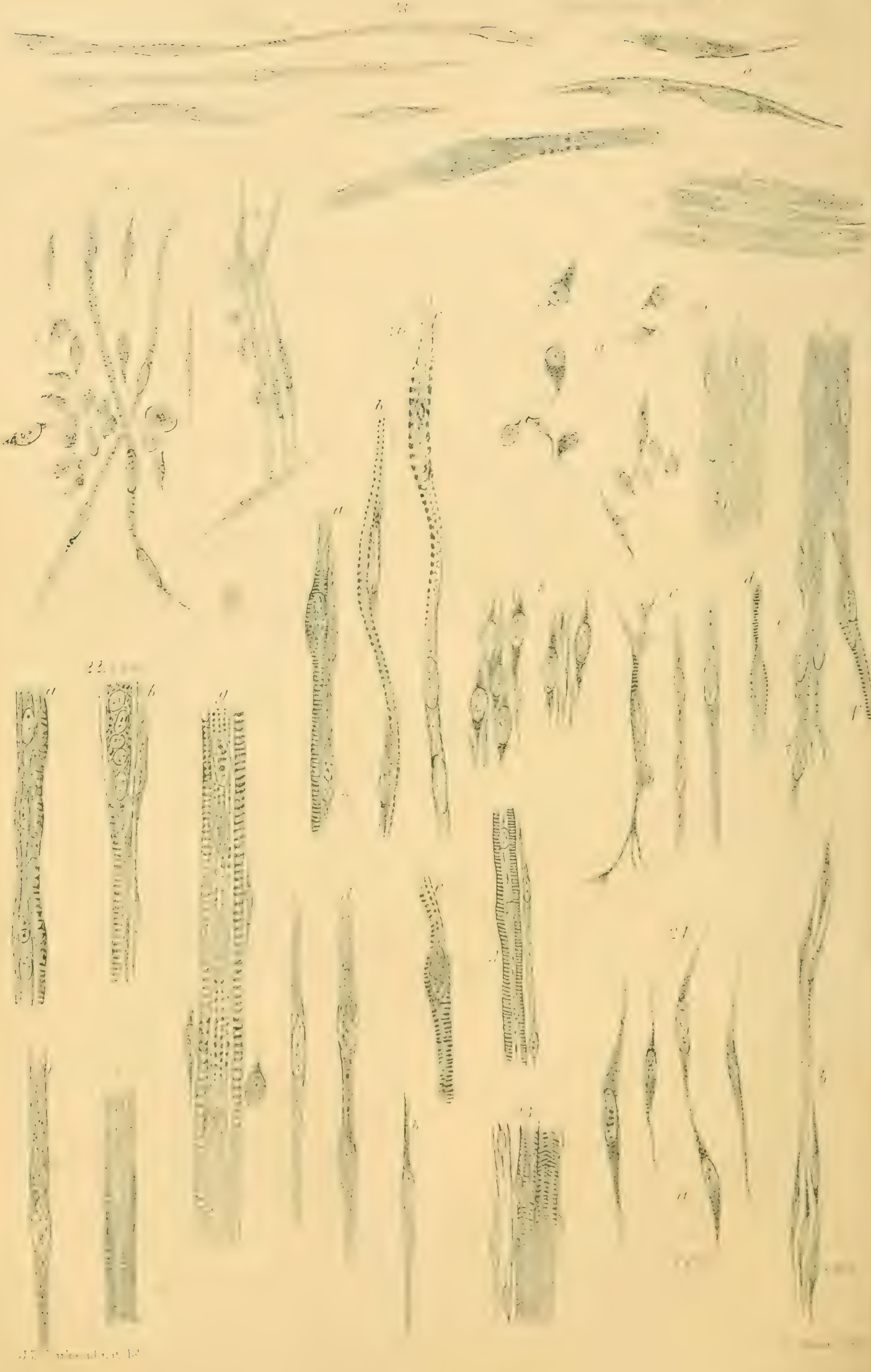


DESCRIPTION OF PLATE I,

Illustrating Mr. J. Lockhart Clarke's paper on the Development of Striped Muscular Fibre in Man, Mammalia, and Birds.

Fig.

18.—Muscular and nerve-fibres from the trunk of a human fœtus of six weeks: *a* are two fibres from the thigh in process of formation, magnified 670 diameters. In the lower one two oval nuclei are united by granular processes proceeding from one of their ends; similar processes extend from their other ends; along one side of the nuclei and processes a thick fibre or lateral band is laid down; in the upper fibre a border is formed on both sides, but is much finer on one side. *b* Is another fibre from the same region, magnified 900 diameters; it is in different states of development at different parts, and is an object of great interest. On one side of the nucleus, at *c*, there are two distinct but smooth borders, and between these the surface of the fibre, as well as of the nucleus, shows indications of longitudinal, but simple or unresolved, fibrillæ. On the opposite side of the nucleus, at *d*, the *lower* border or band, as well as one of the fibrillæ on the surface, has already become resolved into sarcous elements, but the *upper* border, except near the nucleus, has not yet been laid down, and the edge of the fibre is somewhat ragged, with granular blastema, which may be also seen between and beneath the fibrillæ and sarcous elements deposited upon it. *e* Are four delicate nerve-fibres from the same region of the same fœtus.

19.—Muscular fibres and free nuclei from the leg of a human fœtus of two months, magnified 420 diameters.

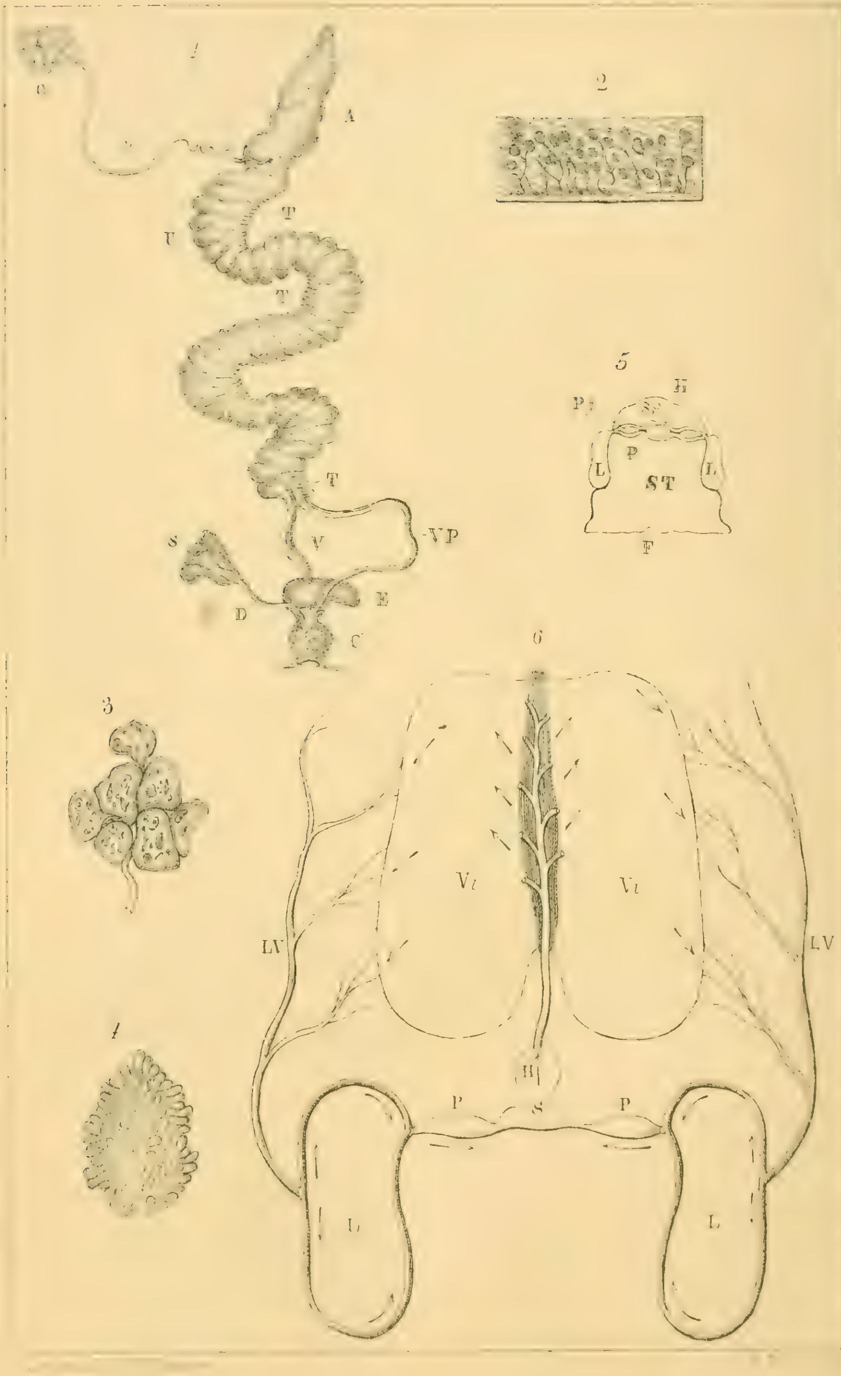
20.—Fibres from the same, magnified 670 diameters: *a* is a striated fibre, consisting of at least two fibrillæ; along one of its sides a nucleus and a layer of blastema have been laid, upon which new fibrillæ are to be laid down. *b* Is another fibre, in which the two fibrillæ composing it are more distinctly seen; nuclei with granular processes are seen along its edge; at *c* part of the lateral bands have become resolved into sarcous elements.

21.—Represents muscular fibres and free nuclei from the ventricles of the heart of a human fœtus $\frac{3}{4}$ inch long, magnified 420 diameters: *a*, free nuclei of different kinds; *b*, nuclei *in situ*, with granular processes and fibres; *c*, different kinds of fibres; *d*, a fibrilla with fine branches resolved into sarcous elements; *e*, fibres collected into a bundle; at *f* the striations are seen.

Fig.
22.—Muscular fibres from the back and leg of a human fœtus, between the second and third month: *a*, a fibre in which the investing sarcous-substance has been formed more thickly on one side than on others. By this unequal growth the nuclei are left near the surface at different parts of the fibre. *b*. A fibre undergoing contraction, and becoming more cylindrical and of more uniform structure; on one of its sides are two nuclei joined by granular process, for the development of a new fibre; magnified 420 diameters. *c*, *d*, *e*, *f*. Smaller fibres from the thigh, magnified 670 diameters; at *e* the transverse striæ are very strongly marked; in the others are seen numerous large and dark granules. *g* Is a larger fibre from the same locality, magnified 670 diameters. *h*. A small fibre from the same, in the first stage of formation; two nuclei are joined endwise by a delicate granular substance, and give off tapering prolongations of the same delicate substance from their opposite ends; along one side of the whole a band or fibre has been formed; magnified 420 diameters. *i*. Another fibre from the same; at its lower part the lateral band or investing substance has increased in thickness, so that the axis is nearly obliterated, and the fibre is of nearly uniform structure; the striations are also strongly marked. *j*. Two other fibres lying side by side; the larger has thick, lateral bands, divided into fine transverse striæ, with a distinct axis, which resembles the other younger fibre at its side; by altering the focus the whole surface of the fibre was found to be striated, as in the large fibre (*g*) in this figure, so that the axis is invested by a tube of striated substance.

23.—Muscular fibres from a human fœtus of four months.

24.—Nucleated fibres of the tendon of a muscle of an arm of a human fœtus two months: *b*, as they are arranged *in situ*; *a*, separated, and more highly magnified.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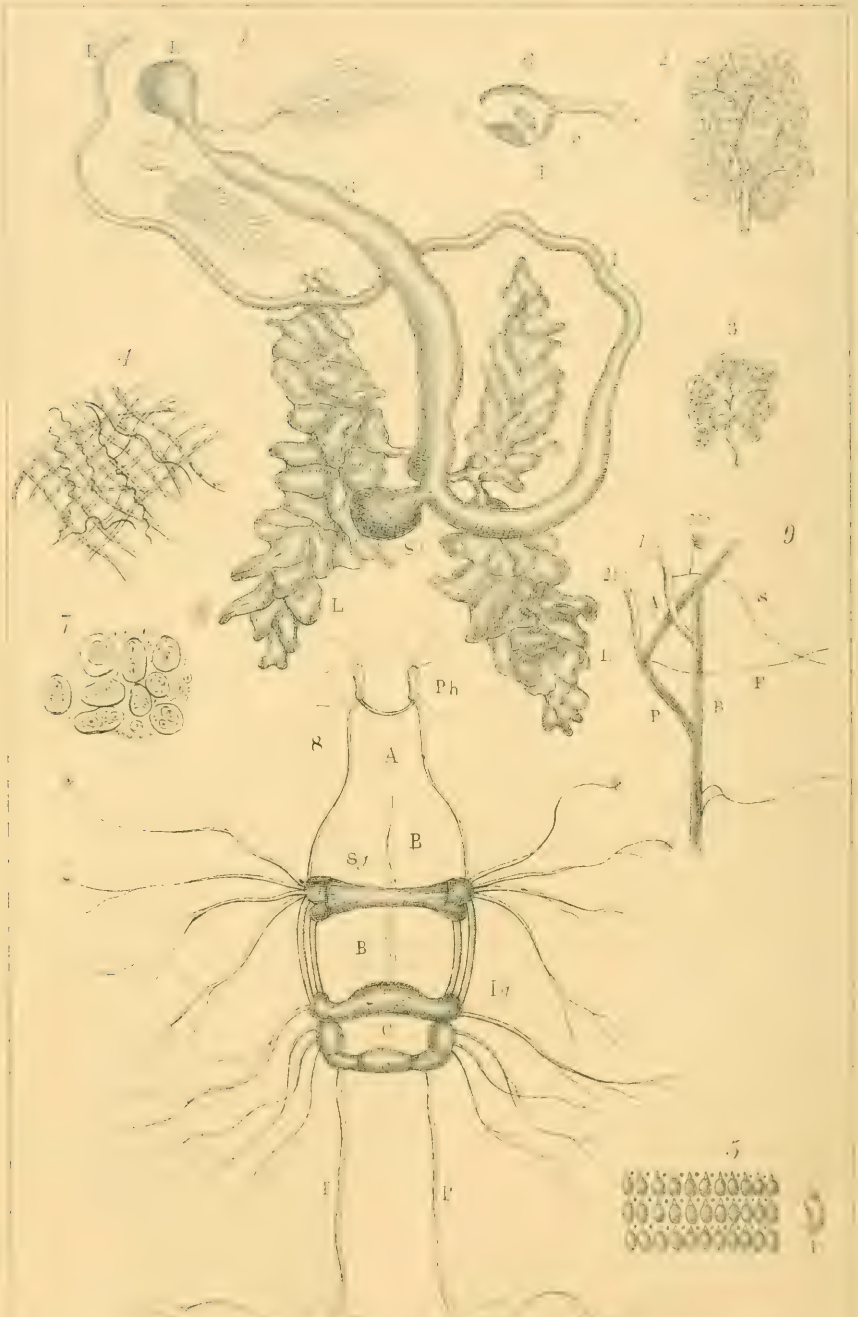
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DESCRIPTION OF PLATES II AND III,

Illustrating Dr. H. Lawson's paper on the General Anatomy, Histology, and Physiology of *Limax maximus* (M.-Tand.).

PLATE II.

Fig.

1.—Complete reproductive system of a fully formed specimen. O, ovary; O V, oviduct; A, albumen gland; U, uterus; T, testis; V, vagina; V P, vas deferens and penis; S, sperm-sac; D, duct of ditto; E, egg-sac; C, cloacal glands.

2.—Vertical section of cloaca, showing peculiar music-note-like glands.

3.—Cluster of ovarian lobules, as seen under compressorium.

4.—Compound, leaf-shaped follicle of testis, much enlarged.

5.—Sectional plan, of relations of heart, lungs, and viscera. H, heart; P g, pericardial gland; P, pericardium; S S, shell-sac; L, lung; S T, sub-thoracic visceral chamber; F, foot.

6.—Diagram of circulation. H, heart; A, aorta; V i, visceral chamber; L V, great lateral vein and branches; L, lung; P, pericardial gland; S, sinus, which plays the part of auricle.

PLATE III.

1.—Entire digestive apparatus of a fully-developed individual. H, head; S, salivary gland; G, gullet; S T, stomach; L, liver; I, intestine; R, rectum.

2.—A lobule of the liver, highly magnified, showing gradual conversion of the duct into the fibrous septa.

3.—Lobules of salivary gland, with circular contained endoplasts.

4.—Strata of muscular tissue from gullet, $\times$ 250, exhibiting intermingled elastic fibres.

5.—Roughened or spinous membrane of tongue. L, single spine seen laterally.

6.—Semi-schematic, vertico-longitudinal section of head. O, oral orifice; T, tongue; P, pharynx; G, gullet.

7.—Ganglionic endoplasts, much increased.

8.—Whole nervous system, enormously enlarged. A, first circle; B, second; C, third; P P, great pedal nerves; P h, pharyngeal ganglia; S g, supra-œsophageal, and I g, infra-œsophageal, ganglia.

9.—Diagrammatic view of the relations of tentacular muscles. S t, superior tentacle; I t, inferior ditto; O t, organ of taste (?); B, basal muscle; P, posterior ditto; A, anterior ditto; S, half of second pair of nerves; F, half of first ditto.

DESCRIPTION OF PLATES IV, V, & VI,

Illustrating Dr. T. Strethill Wright's paper on British Zoophytes.

PLATE IV.

Æquorea vitrina.

Fig.
1.—Planula, directly after leaving the ovary.
2.—Same, a week old.
3.—Same, after having fixed itself to the tank and developed its scleroderm. (Planula now become a polypary.)
4.—Polypary putting forth a polyp-bud.
5.—Same, with young polyp.
6.—Empty polyp-cell.

Atractylis arenosa.

7.—Polyp-stalk, with two opposite ovaries, the scleroderm covered by transparent colletoderm.
8.—Ovary, with colletoderm and scleroderm removed, showing layer of ova packed between endoderm and ectoderm.
9.—Advanced stage of ovary: *a*, ruptured scleroderm; *b*, ectoderm; *c*, endoderm; *d*, secreted cap of "colline."
10.—Ovary ruptured, ova extruded into the cap of colline or *nest*. (The letters correspond to those of fig. 9.)

PLATE V.

Vorticlava Proteus.

1.—*V. Proteus* contracted.
2, 3, 4, 5.—Same, in different states of extension and form.
6.—Diagram of the tissues of the polyp of *V. Proteus*: *a*, colletoderm attached to subtentacular ridge, *b*; *c*, ectoderm; *d*, endoderm.

Acharadria larynx.

7.—Polypary, with two polyps.
8.—Immature polyp.

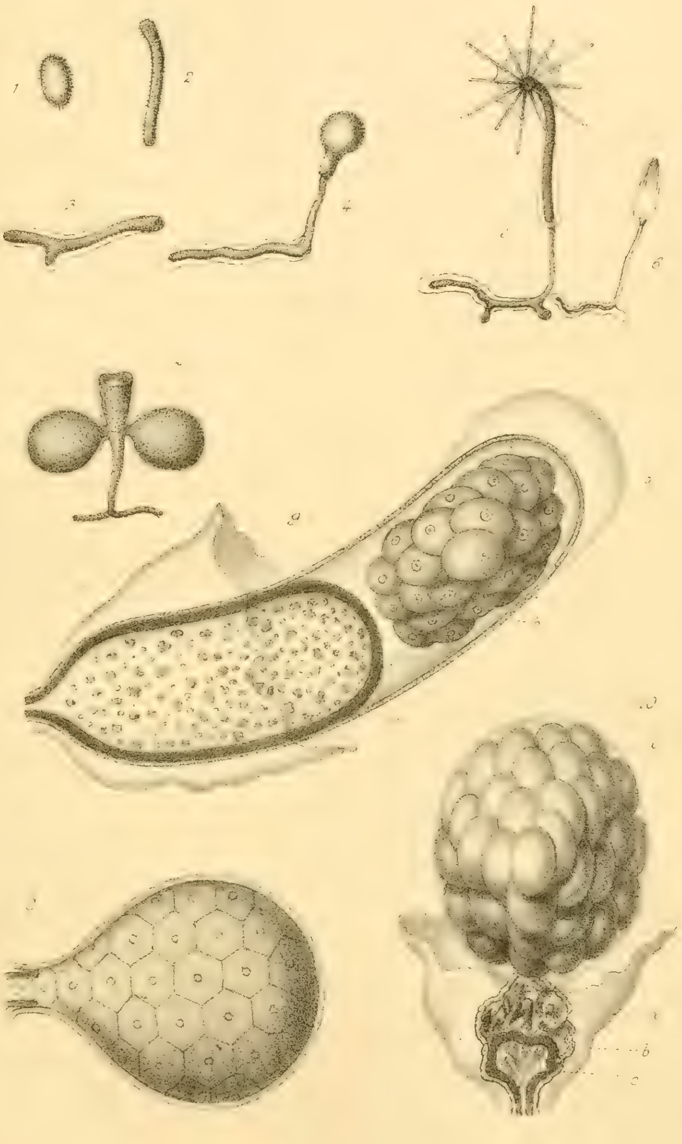
Laomedea decipiens.

9.—Empty cell, showing the double appearance of its border.

PLATE VI.

Trichydra pudica.

1.—Polyp extended, showing the lax habit of the body and tentacles.
2.—Polyp withdrawing itself when disturbed.
3.—Young polyp, with only four tentacles.
4.—Polyp within its tube.
5.—Empty tube.
6.—Supposed Medusoid of *Trichydra pudica*.



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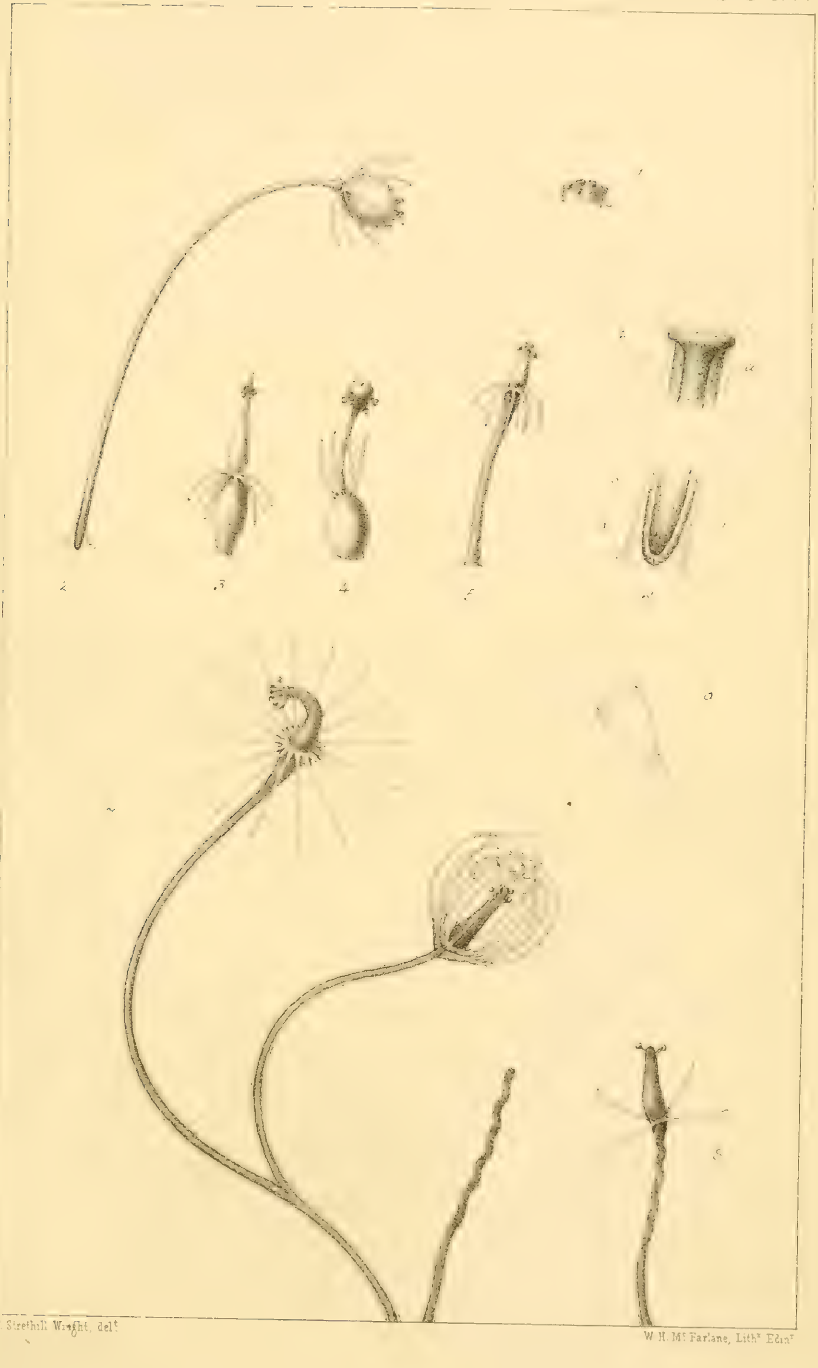

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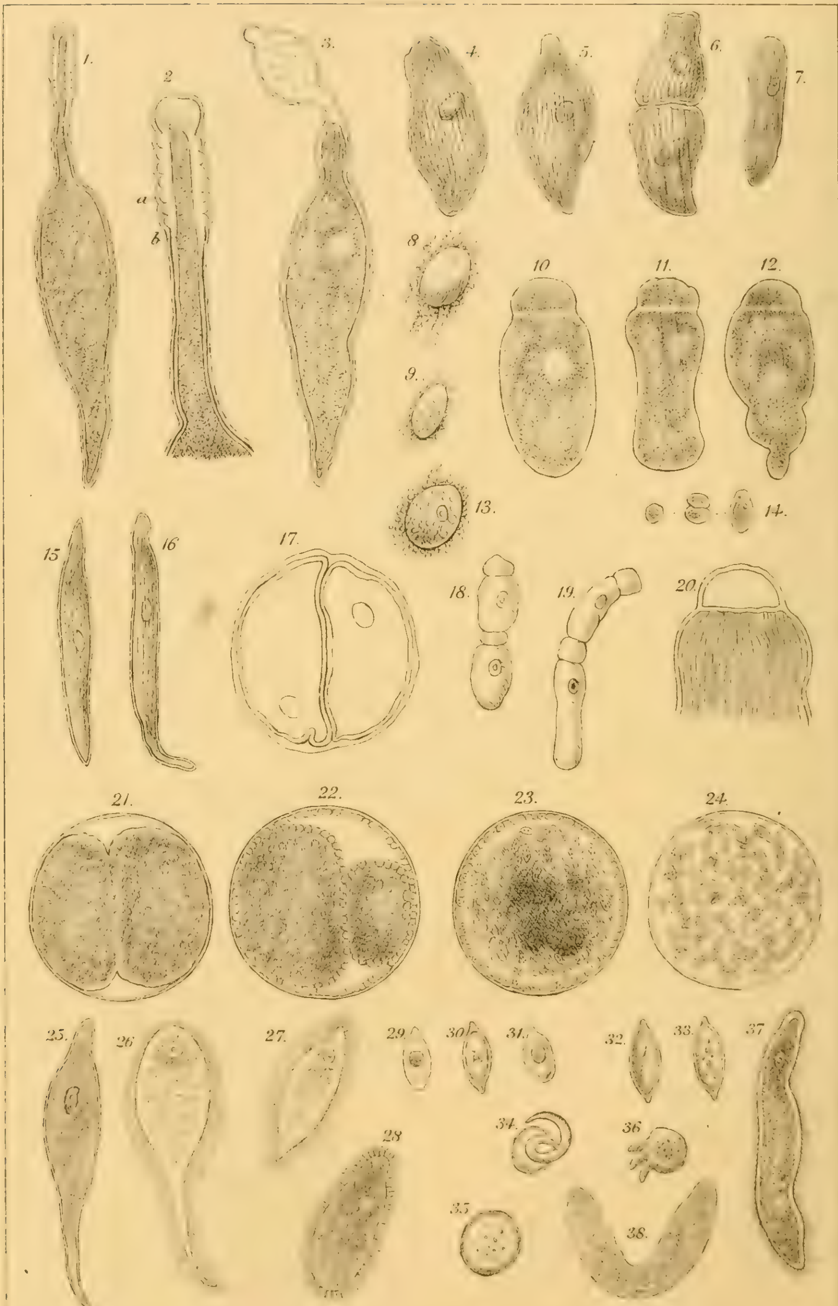


E. R. L. ad nat. del. E. M. Williams, sc.

W. West, imp.

DESCRIPTION OF PLATE VII,

Illustrating E. Ray Lankester's paper on our Present Knowledge of the Gregarinidæ.

Fig.

1.—*Monocystis Aphroditæ, mihi,* from the intestine of *Aphrodite aculeata.* Length $\frac{1}{25}$ inch.

2.—Proboscis of *M. Aphroditæ.* *a*, External membrane; *b*, internal membrane.

3.—Variety of *M. Aphroditæ.* Length $\frac{1}{25}$ inch.

4.—*Monocystis Serpulæ,* mihi, from *Serpula contortuplicata.* Length $\frac{4}{1000}$ inch.

5.—*M. Serpulæ,* with prolongation of membrane. Length $\frac{5}{1000}$ inch.

6.—Two individuals of *M. Serpulæ,* closely attached, as in Stein's genus Zygocystis. Length $\frac{6}{1000}$ inch.

7.—Young individual of *M. Serpulæ.* Length $\frac{2}{1000}$ inch.

8.—Vesicle of *M. Aphroditæ.*

9.—Vesicle of *M. Serpulæ.*

10, 11. 12.—Varieties of *Gregarina Blattarum.* Length $\frac{1}{40}$ inch.

13.—Vesicle of *G. Blattarum.*

14.—Probable young (?) of *G. Blattarum.*

15, 16.—*M. Sabellæ,* from *Sabella* (*Amphitrite*) *infundibula.* Length $\frac{7}{1000}$ inch.

17.—Encysted *G. Blattarum.*

18, 19.—*G. Blattarum* attached one to another.

20.—*G. Blattarum,* showing striated internal tunic.

21, 22, 23, 24.—Stages in encystation of *Monocystis Lumbrici.* Diameter of cyst $\frac{7}{1000}$ inch.

25.—Ordinary form of *Monocystis Lumbrici.* Length $\frac{1}{180}$ inch.

26.—*M. Lumbrici,* variety with fringed envelope. Length $\frac{1}{300}$ inch.

27.—Smaller form of same. Length $\frac{1}{750}$ inch.

28.—*M. Lumbrici,* with envelope composed of conical cells, $\frac{1}{600}$ inch in length.

29, 30, 31.—Pseudo-Naviculæ after their escape from the cyst, in various stages of change. Length $\frac{1}{1400}$ inch.

32, 33.—Pseudo-Naviculæ, Psorosperms, or spindelzells, from cyst of *M. Lumbrici.* Length $\frac{1}{1400}$ inch.

34.—Nematode of Lumbricus escaping from the egg.

35.—Corpuscle from testis of *M. Lumbrici,* probably young of Monocystis. Diameter $\frac{1}{1000}$ inch.

36.—Amœbiform corpuscle from the perivisceral fluid of Lumbricus. Diameter $\frac{1}{1000}$ inch.

37.—*M. Lumbrici,* with fringed envelope. Length $\frac{1}{200}$ inch.

38.—*M. Lumbrici,* containing nucleated granules. Length $\frac{1}{80}$ inch.

DESCRIPTION OF PLATE VIII,

A. Illustrating Dr. Rorie's paper on the Nervous System of *Lumbricus terrestris*.

Fig.

1.—Ganglion from ventral chain of worm.

2.—Nerve-cells of sub-œsophageal ganglion.

3.—Ditto of supra-œsophageal ganglion.

4.—Ditto of one of the ganglia of Mytilus.

B. Illustrating Prof. Max. Schultze's paper on the Structure of the Valve in the Diatomaceæ.

Fig.

1 (1).—A siliceous vesicle produced by the slow decomposition of fluo-silicic acid gas in a moist atmosphere. × 300 diam.

2.—Section of a vesicle, showing the elevations on the surface.

3 (4).—A diagrammatic figure to represent the laminated structure of the elevations of the wall of the vesicle.

4 (5).—The moniliform arrangement of the siliceous particles of which the wall of the vesicle is constituted.

5 (12).—A portion of the surface of a siliceous pellicle, with acuminate elevations, hexagonal at the base.

6 (14).—To show the mode in which, by an alteration of the focus, the appearance of the elevations alters, owing to their laminated structure.

6*a* (14*a*).—A side view of the same.

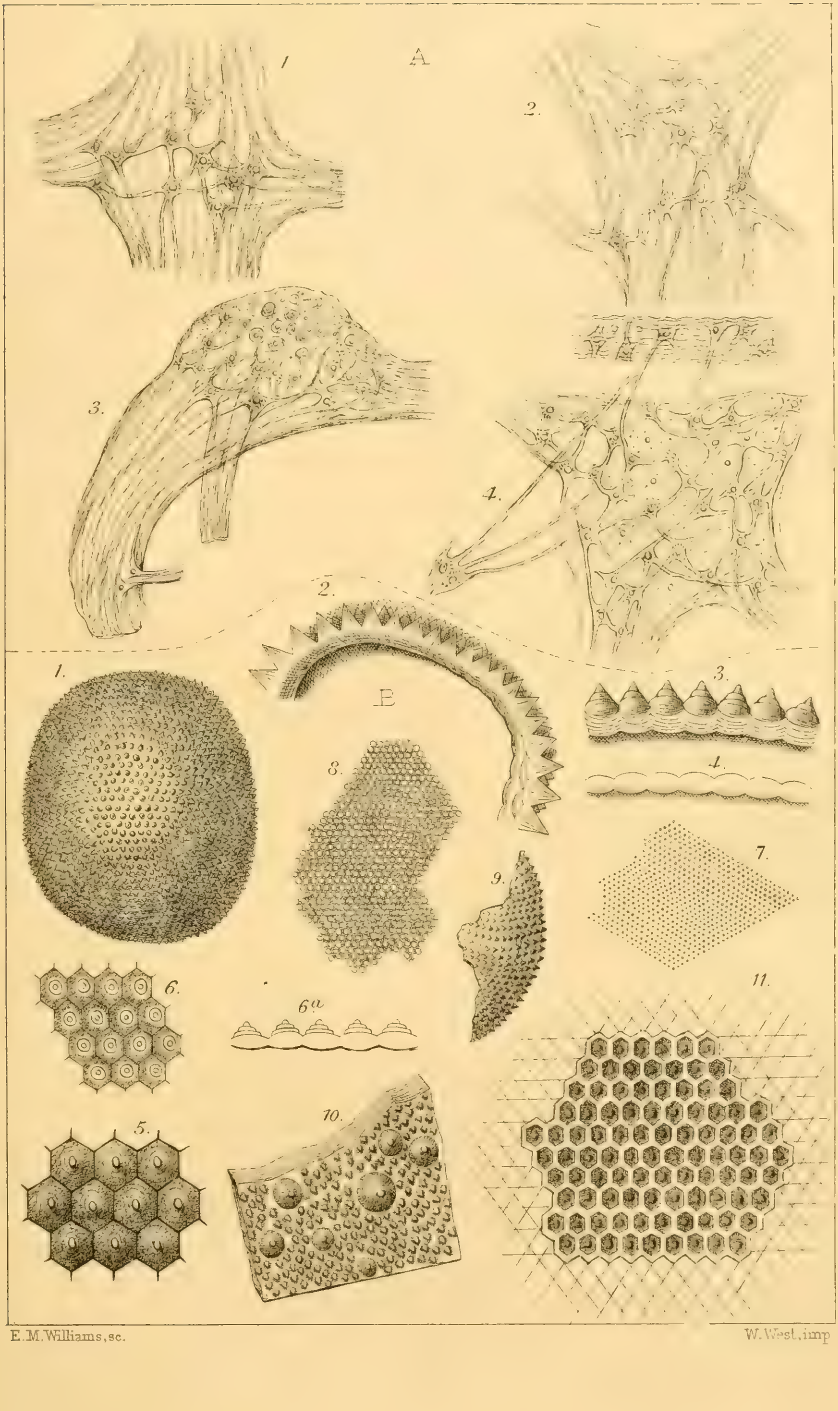
7 (15).—The surface of a thin pellicle, not quite in focus.

8 (16).—The surface of a pellicle, strongly resembling that of a diatom.

9 (17).—The same, viewed on the side, and showing the dots to correspond to elevations.

10 (19).—The surface of a pellicle covered with irregular-sized elevations.

11 (21).—The appearance of *Pleurosigma angulatum* photographed through one of Hartnack's immersion-lenses, No. 10.



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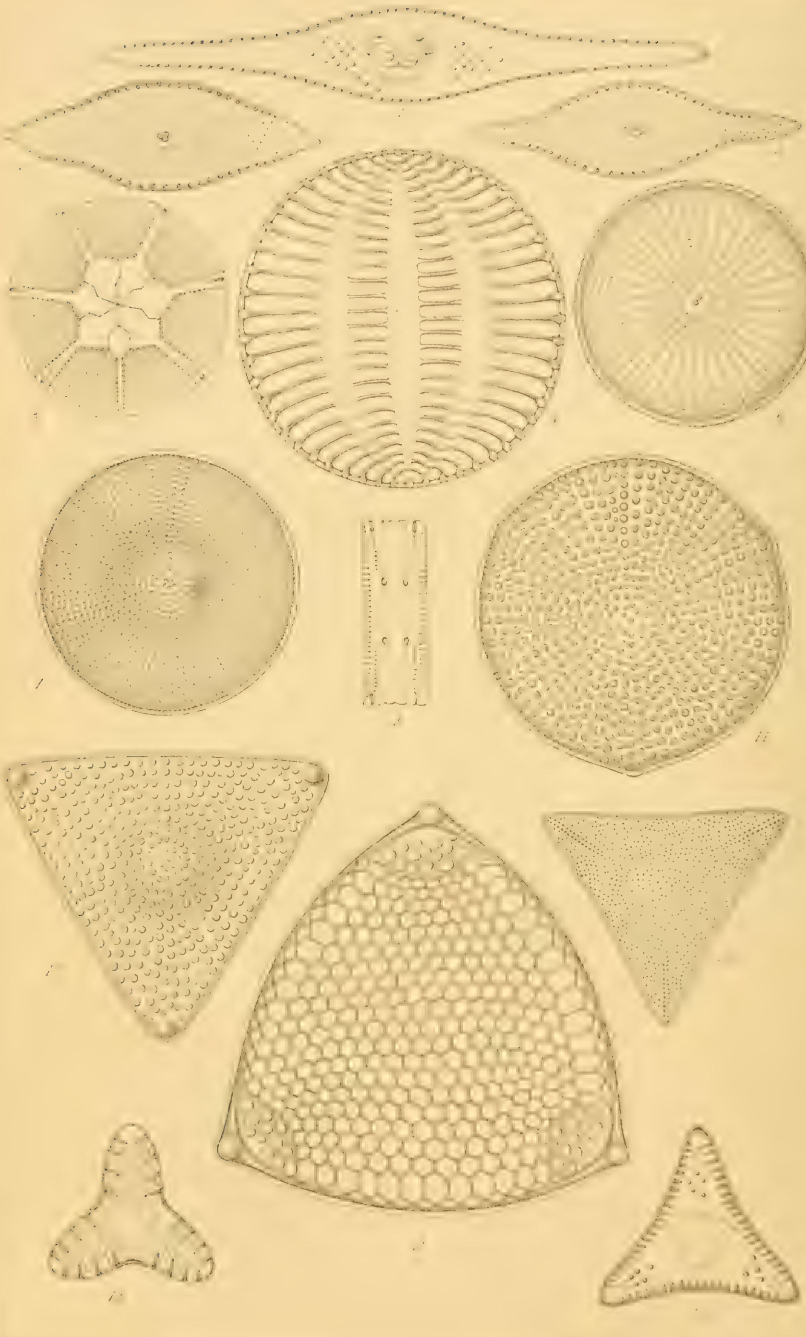


R. K. Greville, del. – F. Huth eng.

W. H. McFarlane Lith. Edin.

DESCRIPTION OF PLATES IX & X,

Illustrating Dr. Greville's paper on New Diatoms. Series X.

Fig.
1.—*Rutilaria Epsilon*, front view.
2.— „ *ventricosa*, „
3.— „ *elliptica*, „
4.—*Campylodiscus undulatus.*
5.—*Grammatophora Moronensis.*
6.—*Coscinodiscus scintillans.*
7.— „ *griseus.*
8.—*Asterolampra Moronensis.*
9.—*Triceratium Robertsianum.*
10.— „ *prominens.*
11.— „ *disciforme.*
12.— „ *cinnamomeum.*
13.— „ *lobatum.*
14.— „ *denticulatum.*
15.— „ *inflatum.*
16.— „ *lineolatum.*
17.— „ *constans.*
18.— „ *tumidum.*
19.— „ *Normanianum.*
20.— „ *subcapitatum.*
21.—*Entogonia amabilis.*
22.— „ *venulosa.*
23.— „ *conspicua.*
24.— „ *punctulata.*

All the figures are × 400 diameters.

CORRIGENDUM.—SERIES IX.

I have committed an error in referring the diatom I have called *Aulacodiscus ? paradoxus* to that genus. It is certainly an *Omphalopelta*. The large, distinct granules, resembling so closely those of various *Aulacodisci*, and the sort of line leading to the processes (not brought out by the engraver) led me at first to doubt its true position.

DESCRIPTION OF PLATE XI,

Illustrating Henry Giglioli's paper on the genus Callidina (Ehren.), with a Description and Anatomy of a New Species.

The letters have the same signification:

a, Trochal disc; *b*, mouth; *c*, pharynx; *d*, mastax; *e*, œsophagus; *f*, stomach; *g*, intestine; *h*, cloaca; *i*, anus; *j*, ovary; *k*, cellular mass surrounding the intestine; *l*, contractile vesicle; *m*, water-vessels; *n*, calcar; *o*, ganglion (?); *p*, vacuolar thickenings; *Q*, head; *R*, body; *S*, tail; *t*, claspers; *u*, suckers.

Fig.

1.—Dorsal aspect of *C. parasitica*, with the trochal disc retracted.

2.—Ventral aspect of *C. parasitica*, the trochal disc being expanded.

3.—Alimentary canal of *C. parasitica*, greatly magnified.

4.—*C. parasitica* attached by its suckers to part of an appendage of *G. pulex;* it is retracted, and shows the corrugations of the integument.

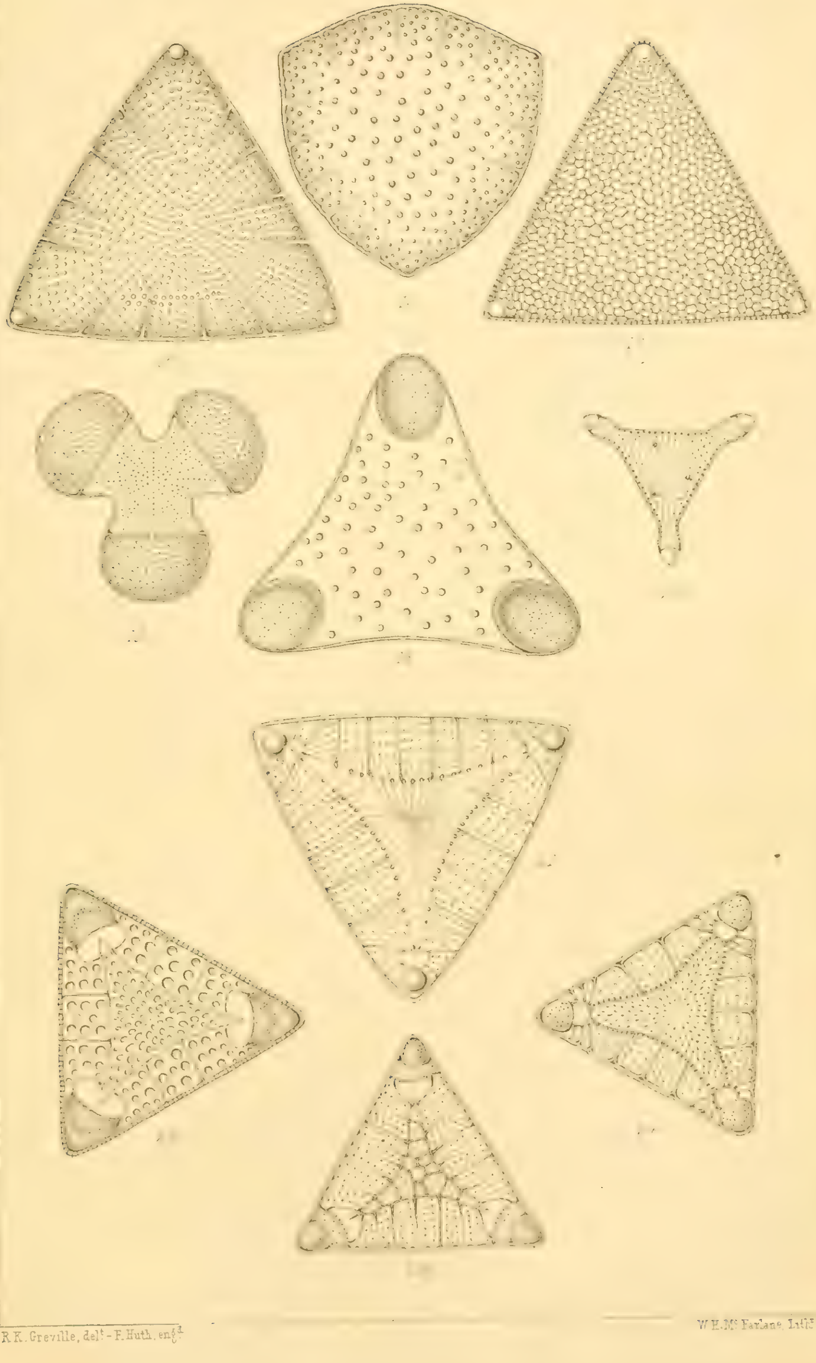
5.—Calcar, much enlarged.

6.—Ovum, recently deposited.

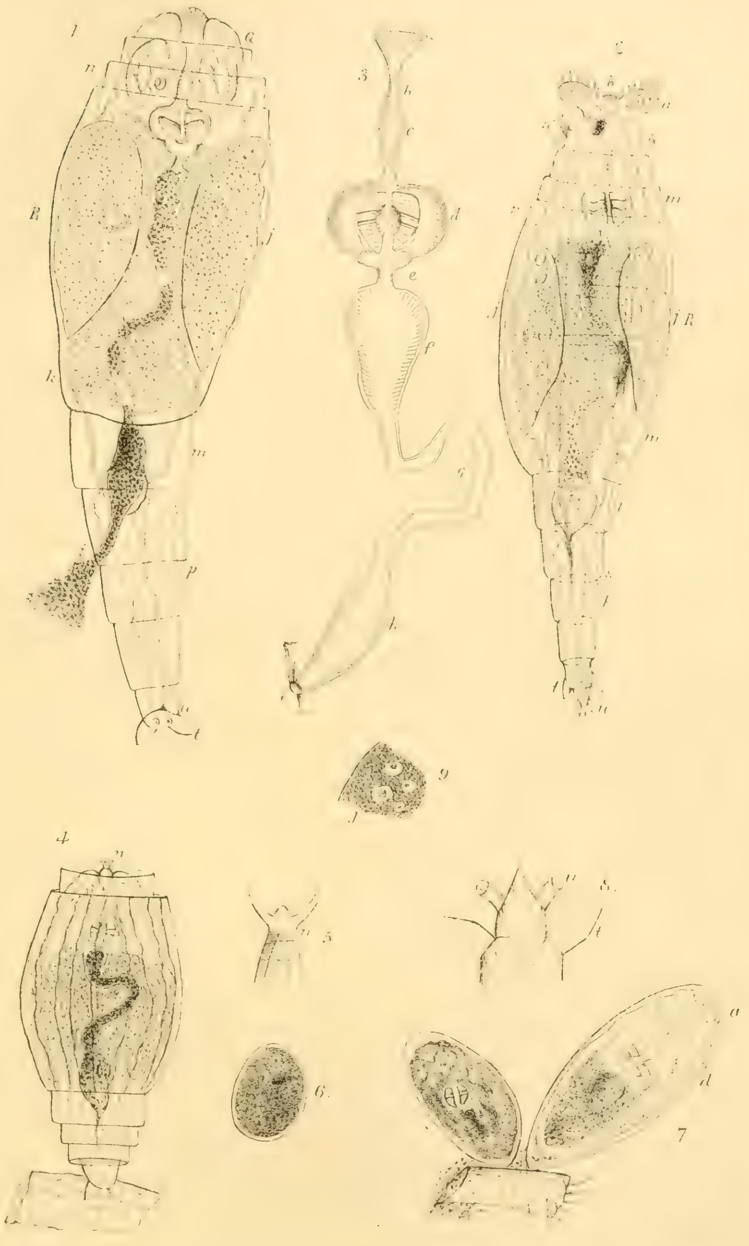
7.—Camera-lucida drawing of two ova attached to part of a thoracic appendage of *G. pulex;* they are magnified 210 diameters.

8.—Caudal appendages (from a camera-lucida drawing), highly magnified.

9.—Portion of ovary, greatly magnified, showing the germinal vesicles and spots.

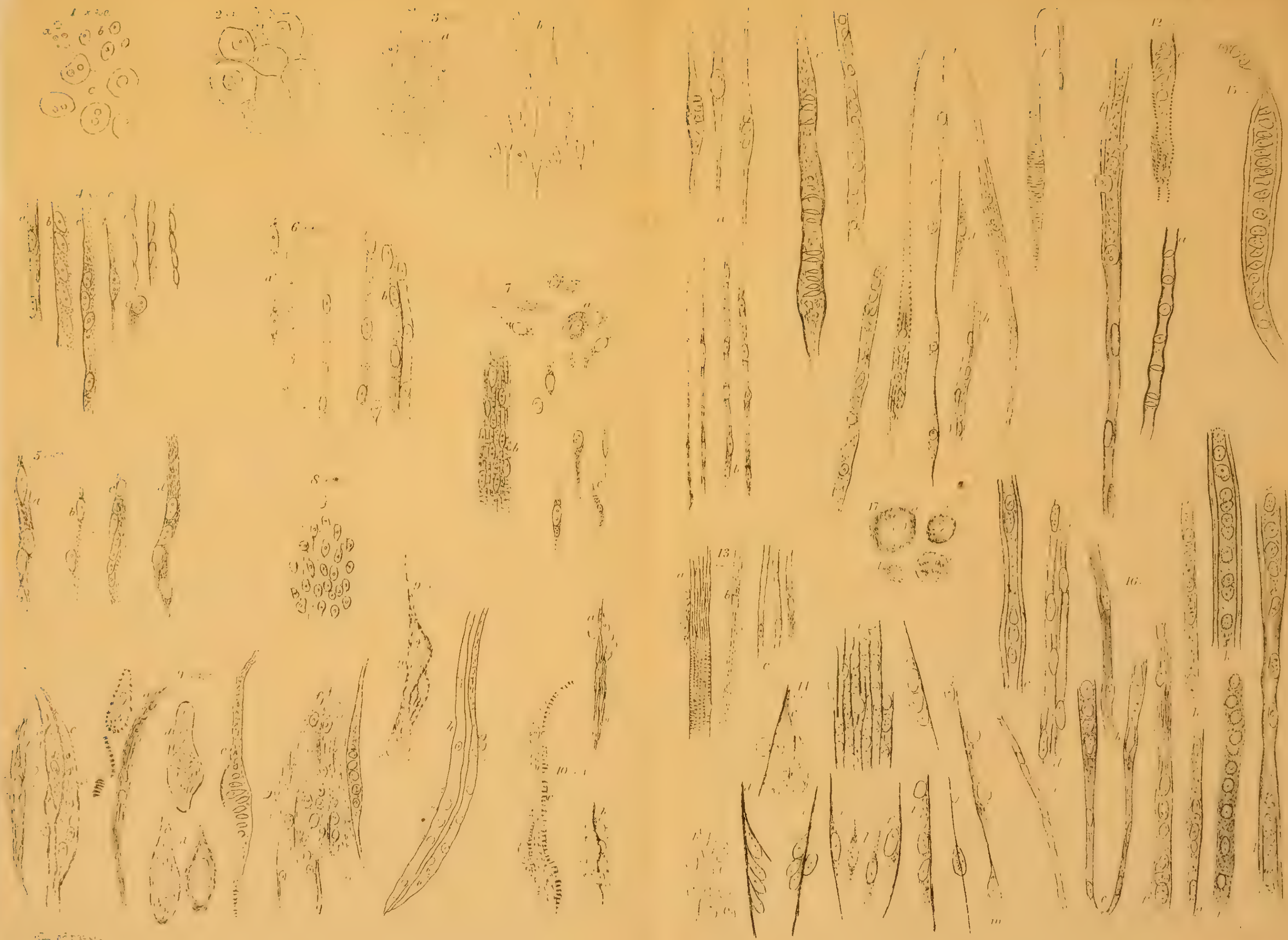


R.K. Greville, del.



H. Giglioli, del. ad viv.

W. West Lith.



DESCRIPTION OF PLATE XI,

Illustrating Mr. J. Lockhart Clarke's paper on the Development of Striped Muscular Fibre in Man, Mammalia, and Birds.

Fig.

1.—Free nuclei and granules from the muscular tissue of the trunk of the domestic fowl at the end of the fifth day of incubation, magnified 900 diameters: *a*, granules of different sizes; *b*, smaller nuclei; *c*, larger nuclei.

2.—Larger nucleated cells belonging to the integument, and surrounded by nuclei, magnified 420 diameters.

3.—Free nuclei and nuclear fibres from the same source, magnified 670 diameters.

4.—Fibres in the first stage of development at the same period, magnified 420 diameters: *a*, *b*, *c*, muscular fibres formed by a series of nuclei, cemented together by a condensed blastema; *d*, a single nucleus, with a granular process, and a fine fibre or fibrilla bounding one side; *e*, a nucleus with one granular process; *f*, fibres of another kind, apparently belonging to tendinous or aponeurotic tissue.

5.—Muscular fibres from the anterior extremity of the chick four hours before the end of the sixth day of incubation, magnified 670 diameters: *a*, *b*, nuclei cemented together by thin, long, granular processes; *c*, a series of nuclei slightly overlapping each other below, and cemented by a column of condensed blastema. This arrangement is only a repetition of that seen at *b*, the processes having coalesced to form the column. *d*. A fibre formed by the coalescence of fusiform granular masses, collected round each nucleus. At its upper part the fibre has become plain and straight.

6.—Fibres from the muscular tissue at the end of the sixth day of incubation, magnified 420 diameters: *a* appears to be a tendinous fibre.

7.—Muscular fibres and nuclear fusiform bodies from the heart of a chick at the ninety-second hour of incubation, magnified 420 diameters: *b*, fibres arranged in a bundle; *c*, *c*, bodies belonging to tendon.

8.—Fibrillation of the blastema between the nuclei, with larger fibres in the muscular tissue, of the chick, on the fifth and sixth days of incubation, magnified 500 diameters.

9.—Muscular fibres in process of formation, ten hours before the completion of the seventh day of incubation, magnified 420 diameters. At *a* several small fibres are seen to enclose nuclei and unite at their extremities; at *b*, *b*, other small fibres have formed on a mass of condensed blastema, and become encrusted with nuclei; *c* shows a number of communicating fibres, with nuclei and condensed blastema between them; *d*, *d*, *d*, portions of similar masses contracted into the form of cells; *e*, *e*, two fusiform fibres, having the appearance of cells; *g*, branched fibres, forming an expansion of condensed blastema with nuclei.

10.—*a*, *b*. Fibres developed in the blastema, in contact with nuclei; *c*, striated fibre under similar conditions, six days and fourteen hours of incubation, magnified 420 diameters.

11.—Muscular fibres of the chick, in different states of development, at the end of the twelfth day of incubation, magnified 420 diameters: *d*, *e*, fibres in the first stage; *h*, two nerve-fibres from a nerve of the leg.

12.—Same kind of fibres from the chick at the end of the thirteenth day of incubation, magnified 420 diameters.

Fig.

13.—Muscular and nerve-fibres from leg of chick on the fifteenth day of incubation: *a*, a large muscular fibre; its upper and lower parts represent the different states of the fibrillæ in different fibres or in different parts of the same fibre; two nuclei are cemented to its side by a layer of blastema. *b*. A smaller muscular fibre, with the fibrillæ here and there divided into sarcous elements; numerous nuclei are attached alternately round its surface. *c*. Three nerve-fibres from the leg.

14.—Muscular fibres and nuclei from the back of a fœtal sheep $\frac{3}{4}$ inch in length, magnified 420 diameters: *a* represents the appearance of the fibres and nuclei in their normal position; *b* are finer fibres connected with nuclei and with the thicker fibres, as at *c*. *d* Is one of the thicker fibres, isolated from the rest; it is formed along the sides, or rather by the coalesced ends of a series of pyriform, imbricate nuclei; a branch of the fibre is formed along the surface of the uppermost nucleus. *d*, *e*, *f*, *g*, *h*, *i*, *j*, *l*, Are other fibres of the same kind, formed along masses of blastema variously connected with nuclei.

15.—Part of a large muscular fibre from the trunk of a fœtal sheep two inches in length, magnified 420 diameters: the axis enclosed by the lateral bands contains numerous nuclei, and a delicate, granular blastema.

16.—Muscular fibres, in different states of development, from the leg of a fœtal ox five inches long, magnified 420 diameters: the period of utero-gestation appeared to be nearly the same as in the case of the fœtal sheep two inches long. *a*. A small fibre in an early state of development; the nuclei, which occur in pairs, appear to be undergoing division. *b*. A broader fibre, with nuclei bulging the surface, but of uniform structure, without lateral bands; *c*, another of a larger kind, with distinct axis and lateral bands; *d*, several small fibres closely applied to each other to form a bundle. At *e* one end of a fibre has a granular axis, with large, nearly round nuclei, and distinct lateral bands; in the middle the fibre is much narrower and uniform in structure, like those at *a* and *b*, with much smaller and oval nuclei; at its other end the fibre again becomes broader, but retains the same uniform structure; the nuclei are still oval, but much larger, and cause the fibre to bulge. *f* Is another fibre, presenting two different states of development; at its lower part it is broader, and consists of distinct lateral borders, with granular axis and nuclei; its upper part, after having assumed a uniform structure with the nuclei at the surface, has become resolved into fibrillæ. *g* Is a fibre in which the border is much stronger on one side; *h*, *i*, are two delicate fibres with scarcely any traces of lateral bands, and resembling the axes of larger fibres, possessing broad lateral bands; *j* is a large fibre, in which the constriction and change of structure have begun in the middle (*j'*); at each end there are distinct lateral bands, and a granular axis with nuclei; in the middle (*j'*) the fibre has become narrower and assumed a uniform structure throughout its thickness, with the nuclei at the surface; *k* is a large fibre, with thick lateral bands; its axis resembles the fibres *i* and *h*, without bands.

17.—Transverse sections of muscular fibres from the leg of a fœtal sheep two inches long: at *a* a nucleus is nearly in the centre; at *b* it is on one side; at *d* and *c* the granular axis is seen to be *surrounded* by the investing substance, which is ultimately resolved into fibrillæ.

Keferstein del.

W. West Lith.

DESCRIPTION OF PLATE XII,

Illustrating Dr. Keferstein's paper on the genus Lucernaria.

Fig.

1.—*Lucernaria octoradiata*, Lam.

st. The stem.
t. Tentacles.
p. Marginal papillæ.
p'. Collection of thread-cells.
n. Collections of thread-cells in natatory-sac.
o. Oral tube.
r. Four lines of connection between the outer and inner membranes of the disc.
r'. The marginal space by which the different radial cavities communicate.
g. Reproductive organs.
m. Longitudinal muscles in the stem.
m'. Radial muscles in the natatory sac.
m''. Circular ditto.

2.—Transverse section of the bell of *L. octoradiata*, carried parallel to the border.

G. Gelatinous disc: *a*, external, *i*, internal, formative membranes; *z*, intermediate substance, with numerous fine fibrillæ.
S. Natatory sac: *g*, sexual organs; *r*, lines of connection between the outer and inner membranes.
R. Radial canals.

3.—Radial section of the bell of *L. octoradiata* through the middle of a radial canal (R). Letters as before.

4.—*L. campanulata*, Lamx., divided by a radial section at about half the height of the bell.

o. Oral tube.
v. Stomach.
s. Point of attachment of the angle or point of the natatory sac to the gelatinous disc.
st. Stem not cut across.
e. Orifices between the points, opening into the radial canals.
f. Internal oral tentacles.
t. Tentacles.
b. Tubercular swelling at the base of the fine tentacles placed nearest to the arm.

Other letters as before. The reproductive organs on the right side have been removed, so as to bring the radial muscular bands clearly into view.

5.—One of the tentacles with a swollen base, viewed laterally.

6.—Tentacle of *L. octoradiata*.

7.— „ *L. campanulata*.

8.—Thread-cells from the *capitulum* of the tentacles of *L. campanulata*.

PLATE XII (*continued*).

Fig.

9.—Inner membrane lining the natatory sac of *L. octoradiata.* × 260 diameters.

10.—Transverse section of the stem of *L. campanulata*: *a*, outer, *i*, inner, cellular coat; *z*, transversely striated intermediate substance; *l*, the four internal ridges.

11.—Longitudinal section of the same, carried in the direction $\alpha\ \beta$ of the foregoing figure; *k*, cæcal hollow in the pedal disc. Other letters as before.

12.—Longitudinal section through the foot, in order to display the cæcal hollow more plainly. Letters as before.

13.—Transverse section through the stem of *L. octoradiata.*
h. The four longitudinal channels which replace the central cavity.

14.—Glandular inversion of the wall of the natatory sac (s) of *L. campanulata*, indicated at *n* in fig. 4; *x*, orifice by which the thread-cells can be expressed.

15.—Thread cells: *a*, with extended filaments still enclosed in the parent cell. × 260 diameters.

16.—Internal oral tentacles of *L. campanulata.*

17.—Transverse section of the same, showing the extent of the glandular, thickened part of its wall.

18.—Zoosperms of *L. octoradiata.*

Distribution of finest nucleated-Nerve Fibres to the Elementary Muscular Fibres of the Mylo-hyoid Muscle of the little Green Tree Frog (Hyla Arborea). Drawn on the block by the Author, from a specimen magnified 1700 diameters (the first twenty-fifth made by Messrs. Powell & Lealand). The diameter of each muscular fibre corresponds to that of a human red blood-corpuscle.

SCALE. $\frac{1}{10,000}$ of an English Inch × 1700 diameters.

DESCRIPTION OF PLATE XIII,

Illustrating Lionel S. Beale's paper in the "Proceedings" on Further Observations in favour of the View that Nerve-fibres never end in Voluntary Muscle.

Distribution of finest nucleated nerve-fibres to the very narrow elementary muscular fibres of the mylo-hyoid of the little green tree-frog (Hyla arborea), *magnified* 1700 *diameters. Drawn on the block by the author.*

The elementary muscular fibres are marked *g*, *h*, *i*, *k*. *k* Is a very young one, slightly stretched; *i* is a fully formed muscular fibre; *h*, another stretched in its central part. The nuclei of these fibres exhibit some differences in size and form. Nucleoli are distinct in all, and in the fibre marked *g* the nuclei, which were coloured by carmine, exhibit three different intensities of colour—the dark central spot, "nucleolus," being most intensely coloured, as indicated by the shading in the drawing.

a Is a nerve-fibre which was followed over more than twenty elementary muscular fibres from a dark-bordered fibre. One of the subdivisions of this fibre is seen at *f*, where it again runs with a very fine dark-bordered fibre (*o*). The dark-bordered fibre (*o*) was some distance higher up in the specimen, but its place has been altered in order to avoid the necessity for a still larger drawing. Above *b* a nucleus of a very fine nerve-fibre is seen. Such nuclei lie upon the surface of the muscular fibres, external to the sarcolemma. The nucleus often *appears* as if it were within the sarcolemma (*c*), but the fibres proceeding from each extremity render such a position impossible. The relation of these nerve-nuclei to the sarcolemma is seen at *l* in profile. The nuclei, as well as the fibres for a certain distance, often adhere to the sarcolemma very firmly; but in the thin mylo-hyoid muscle the course of the fibres over or under, but always *external*, to the muscular fibres, may be readily traced if the muscular fibres be separated slightly from each other, as represented in the drawing.

At *d* fine nerve-fibres accompanying the fine fibre continued from the dark-bordered fibre, as described in the 'Philosophical Transactions' for 1862, are represented. Such fibres are also seen at *e* and *f*.

m, *n*, and *o*. Dark-bordered fibres, with nuclei near their distribution. *m* Would probably pass over sixty or seventy muscular fibres, and *n* over perhaps twenty, before it divided into fibres as fine as those seen at *b*, *e*, *f*, *l*.

p. A very fine capillary vessel with a nerve-fibre running close to it.

q. A bundle composed of six very fine nerve-fibres near their distribution. These fibres exhibit a very distinctly beaded appearance, which is also observed in many other fine fibres in different parts of the specimen.

Traces of connective tissue are seen in all parts near the fine nerve-fibres and around the muscular fibres. Here and there some very fine connective-tissue-fibres, which were not altered by acetic acid, are represented. These represent the remains of fine nerve-fibres, which existed in a state of functional activity at an earlier period.

The drawing, with the exception of the position of the nerve-fibre (*o*) above mentioned, is an actual copy from nature. The relative position of the muscular fibres, the form and general character of the so-called nuclei, and the position and size of the nerve-fibres and their nuclei, have been carefully preserved.

I have traced the very fine nerve-fibres in so many instances from one trunk to another ramifying at a very considerable distance, that I cannot believe any true terminations or ends exist.