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XXII. *Observations on the Minute Structure of some of the higher forms of Polypi, with views of a more Natural Arrangement of the Class. By* ARTHUR FARRE, *M.B. Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. Communicated by* RICHARD OWEN, *Esq. F.R.S.*

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TO attempt the reformation of any class in the animal kingdom,—the numerous individuals of which are widely spread over the surface of the globe, many therefore difficult of access, and others, though easily obtained, yet extremely perishable, and for the most part so minute, as to require for their examination the utmost penetration of the microscope and unwearying perseverance in the observer—is a task of no little difficulty in the accomplishment, and one that may fairly entitle him who enters upon it to expect to meet with indulgence.

It is probably owing to these retarding circumstances that the class Polypi, as now generally understood, presents such a heterogeneous accumulation of widely differing structures as is perhaps to be found in few similar portions of the animal kingdom: and it is only by a strict investigation of the *intimate structure* of the various forms of animals that have been so indiscriminately heaped together, that any permanent arrangement that shall indicate their true and natural affinities may be hoped for.

The slightest glance at the history of the revolutions which the ideas of naturalists have undergone, with reference to this class since it first became known, will establish the truth of this position, and show the importance of attending to the entire organization of the animal, as far as it can be known, in any attempt at classific arrangement.

It is not wonderful, indeed, that a class of animals to which the name Zoophytes has been so long and universally applied, a name sufficiently expressive of the dubious position which they were supposed to hold in the kingdom of nature, should by the earlier naturalists have been referred entirely to the vegetable or even to the mineral kingdom; and accordingly we find that in the seventeenth century many of these were described as minerals by BOCCONE and GUISON; and by CESALPIN, BAUHIN, LOBEL, TOURNEFORT and RAY as vegetables; the great quantity of earthy materials, produced by many forms of Zoophytes, leading to the former supposition and giving rise to many theories, as to the growth of stones, &c.; whilst the more obvious external characters and habits would, under deficient means of observation, readily favour the latter. And this supposed alliance with the vegetable kingdom seemed to be still further strengthened when, in the commencement of the following century, the animals of some species of coral were described by Marsigli as flowers.

This circumstance perhaps more than any other tended to confirm botanists in claiming these bodies for the vegetable kingdom, notwithstanding that it was maintained by chemists that their structure exhibited more of an animal than a vegetable nature, and that even so early as the sixteenth century the animals of several had been distinctly described as such by Imperati.

The discoveries and opinions, however, of this observer, who appears to have been the first to ascertain the animal nature of these Zoophytes, as well as the observations of Rumphius made upon many of the living corals in the Archipelago, seem to have been entirely neglected and forgotten; nor does it appear that the botanical theory was disturbed until a similar discovery to that of Imperati was communicated to the Acad. des Scien. in 1727 by Reaumur, founded upon the observations of Peyssonell, who maintained that the supposed flowers of Marsigli were in fact aggregate animals analogous to Actinia, which latter animal was then, perhaps, the only one of the class to which a vegetable nature was not generally ascribed.

This communication seems to have directed the attention of naturalists more immediately to the subject, and the subsequent discoveries of Trembley of the naked Polypi, in 1740, and the investigations of Bernard de Jussieu, Guettard, Læfling and Donati, were greatly instrumental in pointing out the true nature of Zoophytes. But by none was the investigation pursued to so great an extent as by the indefatigable Ellis, whose systematic work was the first of the kind that appeared upon this subject. In maintaining the entire animality of Zoophytes Ellis was strongly opposed by Linnæus, Baster, and Pallas, who still holding an opinion midway between the two that divided naturalists, maintained that they were of a mixed nature, partly animal and partly vegetable.

With Linnæus, however, and his contemporaries this view of the subject ceased, and subsequent investigations have completely exposed the fallacy, both of the vegetable and vegeto-animal theories. But the work of Ellis, as well as that of Pallas on the same subject, can be considered as but little more than a classification of the more solid, or least perishable, and least important parts, (the part called Polypary by Reaumur), without reference to the structure of the individual animals, which was then little understood, and was generally supposed to partake in all these cases of the simple nature of Hydra, and they were therefore so called by Linnæus.

This mode of classification, by no means likely to lead to a natural arrangement of the subject, was from the same cause adopted in the more recent systems of Lamark and Lamouroux, where the characters of the axis or polypary are again taken as the basis of arrangement; though a considerable advance is made in founding secondary divisions on the structure and form of that part of it, which is immediately inhabited by the individual animals, commonly called the cell. Still, however, from a deficiency of knowledge the most important parts are disregarded, and animals frequently united even in the same *genus* which have not a *classical* relationship.

But RENIER and SAVIGNY had already shown that the animals of Botryllus and Alcyonium, LINN., were not, as had been generally supposed, Polypes, but possessed a structure similar to that of Ascidia; whilst the descriptions and figures given by various writers of some of the cortical Polypes showed that these were closely allied to Actinia.

But though some of the larger forms had been thus more accurately investigated, the hundreds of minute species that remained must necessarily have escaped observation, until the more general use of the microscope and the great improvements lately made in that instrument, opened up a wide and almost entirely new field of discovery, which the inefficient instruments of previous investigators had only just enabled them to enter upon.

By this means the currents observed by SPALLANZANI to be produced by some of these animals, and attributed by him to the action of the arms, were shown by STEINBUCH*, by FLEMING† in Valkeria, and by GRANT‡ in Flustra, to be due to the vibration of cilia, by which the sides of the tentacula were fringed; and to the last-mentioned naturalist we are also indebted for many important observations on the ciliated reproductive gemmules of this family, on the form and growth of the cells, and on the digestive cavity.

It was shortly after discovered by MILNE EDWARDS and AUDOUIN that some of these compound polypes possessed an *anal* as well as an *oral* opening to the alimentary canal; a discovery which EDWARDS communicated to the Acad. des Sciences in 1828§, and proposed thereupon to found a division of the class Polypes into different families, according to the forms of the alimentary canal. In this class, however, he also includes Sponges.

A similar discovery was also made about the same time by EHRENBERG, independently of that of EDWARDS, and was taken by him as the basis of his classification of Polypes‖, dividing these animals into two principal groups, Anthozoa and Bryozoa, according as the alimentary canal has one or two external openings; a division which he has since (1835) modified by separating the Sertulariæ and other hydriform Polypes, which form a third group denominated by him Dimorphæa.

This type of structure, observed shortly after (in 1830) by THOMPSON¶ in Ireland,

* Analecten Neuer Beobachtungen und Untersuchungen für die Naturkunde 1802, p. 89, quoted by Dr. SHARPEY, Cycl. Anat. art. Cilia, p. 609.

† Mem. of Wern. Soc. Fol. Part V. p. 488.

‡ Edinburgh New Philosophical Journal, vol. iii. 1827.

§ Résumé des Recherches sur les Animaux sans Vertèbres, faites aux îles Chaussay, par MM. AUDOUIN et MILNE EDWARDS. Annales des Sciences Naturelles, t. 15. Sept. 1828; and Recherches Anatomiques, Physiologiques et Zoologiques sur les Eschares, par M. H. M. EDWARDS. Ib. t. 16. Juillet 1836.

‖ Symbolæ Physicæ.

¶ Zoological Researches and Illustrations, Memoir V. Cork, 1830.

apparently without a knowledge of the discoveries of Edwards and Ehrenberg, was described by him as indicating a new form of animal, to which he applied the name Polyzoa, to distinguish them from such of the compound animals as partake of the nature of Hydra, and he proposed to elevate them to the class of tunicated Mollusca.

The existence of this type in Flustra has also been since demonstrated by Mr. Lister, in his paper on "Tubular and Cellular Polypi," communicated to the Royal Society in 1834; which contains also much new and valuable information relative to the economy of the more simple or hydriform Polypes.

The descriptions and illustrations of these last-mentioned observers are in various degrees confirmatory of each other, and are sufficient to indicate in a general way the characters of this more recently discovered form of animal; but the uses of their various organs are often confused and misunderstood, and their minute structure certainly not investigated with that degree of accuracy which it deserves, and which the present state of science demands.

It is with the view of supplying these deficiencies that I am induced to lay before the Society the result of my own observations upon this very interesting portion of the animal kingdom, conceiving that they have been prosecuted to an extent that has not hitherto been effected.

My attention was first particularly directed to the subject in the year 1835, during a short visit to the Isle of Sheppy, for the purpose of exploring the various animal productions, so abundant on that portion of our coast. During this visit the type of structure here referred to came under my notice, and the results of my investigations upon it were then so entirely new to me, that I was induced to repeat these visits at intervals; and upon the specimens thus procured, and also upon similar supplies obtained from the same place, which I have repeatedly received from my friend Mr. Bowerbank, I have been enabled to continue the investigation beyond the limits that a mere temporary visit to the coast would have enabled me to do.

During the early part of these investigations I was but little acquainted with the observations that had already been made by others upon the subject. But having since been necessarily led to consult these, I find some of my own investigations in various degrees confirmed. Those points therefore that are not new I have either wholly omitted, or touched upon only to the extent that would be necessary to render the subject intelligible.

The facts that I have thought the most interesting and important to be stated are embodied in the descriptions of the various species that furnish the subject matter of the present memoir. Two of these species I believe to be entirely new, and I have ventured to name them accordingly.

A few particulars with regard to the method that I have pursued may not be without their use, though each specimen will frequently require a different manipulation.

A number of glass troughs being at hand (which with the aid of a little cement may be easily constructed of every variety of depth), these should be filled with sea water, and a specimen of the species to be examined placed in each, care being taken to adapt the depth (from side to side) of the trough to the thickness of the specimen, it being very desirable that no more water should intervene between the latter and the sides of the glass than is just sufficient for the purpose.

If the specimens are tolerably recent it will seldom fail that in a short time the animals, which always contract the instant that they are disturbed, will begin to expand themselves, in which state many may be observed by the naked eye, and a very cursory glance under the instrument will then show which are the best adapted for observation.

For this purpose it is necessary that a clear reflected light should be transmitted through the object, care being taken to avoid all artificial light, which is totally inadequate to supply that delicate and perfect definition requisite for the examination of objects so extremely minute as those which form the subject of the present essay. This method, which if rigidly pursued, greatly limits the time during which the investigation may be continued, is yet the only one that can be safely trusted to; and for subjects of this nature I have therefore long ceased to use any other than a clear *daylight**.

The figures which are added in illustration were drawn from the specimens by being previously outlined by the aid of a camera lucida attached to a reserve eyepiece, to allow of its being instantly substituted whenever a favourable specimen should present. By this means a faithful record of appearances is preserved that cannot be equalled, and indeed hardly obtained by other means, although it is scarcely in the power of a drawing to convey an adequate idea of the exquisite beauty of the living objects.

PLATE XX. and XXI.

Bowerbankia densa†, Mihi.

Fig. 1. Found commonly on *Flustra foliacea*, thickly aggregated in masses of half of an inch to one inch diameter.

* The very perfect instrument, in the possession of my brother, with which I have been enabled to make these observations, was constructed by Mr. Ross, of London, to whom the greatest credit is due for the perfection to which he has brought his glasses.

† This I believe to be either entirely new, or to have been confounded with the *Grape coralline* of Ellis, (Corall. pl. xv. f. 25. c. C. D.) the *Valkeria uva* of Fleming (Brit. Anim., p. 551. gen. lxx. 197.), &c. Whatever be the animal meant by Ellis, it certainly differs materially from the present species, which I cannot refer to any described genus with which I am acquainted. Believing it to be new I have named it after my friend Mr. Bowerbank, whose zeal displayed on this as on many other occasions where the study of natural history may be promoted, was mainly instrumental in inducing me to follow up these investigations, on account of the many supplies that I received from him, and I gladly therefore take the opportunity of acknowledging and recording the obligation that I am under to him.

Fig. 2. The animal when fully expanded is about one twelfth of an inch in length. In its retracted state it is completely inclosed in a delicate horny cell, sufficiently transparent to admit of the whole structure of the contained animal being seen through its parietes. The cells are connected together by a cylindrical creeping stem, upon which they are thickly set, and sessile, ascending from its sides and upper surface.

Fig. 3. *a*. The animal when completely expanded is seen to possess ten arms of about one third the length of the whole body, each arm being thickly ciliated on either side, and armed at the back by about a dozen fine hair-like processes, which project at nearly right angles from the tentacula, remaining motionless, while the cilia are in constant and active vibration.

The tentacula are united together at their base to form a circle, in the centre of which is the mouth, and from which descends the œsophagus (fig. 3. *a* 1), bulging a little at its commencement, and then contracting and passing down nearly straight to its termination. The parietes of the œsophagus, especially at the upper part, which may be more correctly denominated the pharynx, are thickly studded with minute oval spots, arranged closely in contact with each other (Plate XXI. fig. 8.). The whole organ appears to be highly irritable, and contracts vigorously when food is introduced into it.

At the termination of the œsophagus is a distinct cardiac orifice (fig. 3. *a* 2.) that opens into a small globular cavity (*a* 3.) of singular construction, which appears to perform the office of a gizzard. The parietes of this organ are thicker than in any other part of the alimentary canal. They contain two dark round bodies placed opposite to each other, from each of which dark lines are seen radiating. In the space between these two dark bodies may be seen a number of squamiform spots arranged closely in contact, and presenting a beautifully regular tessellated appearance. This appearance was at first supposed to be owing to the crossing of the radiating lines at this point (fig. 4.); but a more accurate examination convinced me that they were distinct bodies lining a part of the interior of the cavity, and probably performing the office of gastric teeth: they have a remarkably definite outline when viewed under favourable circumstances, and by tearing open the gizzard, or bursting it by pressure, may be separated from its inner surface (Plate XXI. fig. 7.). The two dark bodies appear to be the points at which the radiating lines are concentrated. When the organ is in a state of rest and viewed laterally, these are seen projecting into the cavity, and giving it an hour-glass form (fig. 5.); but when it contracts these bodies become elongated, and their inner surfaces are closely applied to each other, and the cavity is obliterated (fig. 6.). The alterations in the form of this organ appear to be entirely due to these apparently muscular bodies. They are conspicuous even in animals not yet arrived at maturity (fig. 3. *c* 1.).

This organ, which I shall call the gizzard, opens downward into the true digestive stomach (fig. 3. *a* 4.), an oblong cavity terminating below in a blunt extremity, and from which it is separated only by the contraction of the parietes. The entire walls of the stomach are thickly studded with spots of a rich brown colour. These appear to be hepatic follicles, and to prepare a fluid that tinges the whole organ, as well as its contents, of a similar hue.

From the upper part of the stomach, and by the side of the entrance from the gizzard, arises the intestine (*a* 6.), by a distinct pyloric orifice (*a* 5.) that is surrounded by vibrating cilia. The intestine passes up straight and narrow by the side of the œsophagus, from which it is entirely separate and free, and terminates by a distinct anal orifice (*a* 7.) in the delicate parietes of the body, close to the outer side of the tentacular ring. The parietes of the intestine are marked with pale spots, something like those of the pharynx, and the whole tube, like the rest of the alimentary canal, possesses a high contractile power. Thus the alimentary canal consists of pharynx or œsophagus, gizzard, stomach and intestine, with subsidiary secreting follicles, and distinct oral, cardiac, pyloric, and anal orifices. The whole floats freely in a visceral cavity, the boundaries of which are formed by the delicate transparent parietes of the animal; the space between the alimentary canal and the parietes being occupied by a clear fluid, and by the muscles which act upon the animal.

That the animal possesses distinct membranous parietes separate from the walls of the alimentary canal, and independent of the cell which it inhabits, does not at first sight strike the observer, but the slightest attention to points hereafter to be mentioned will place this matter beyond a doubt.

The transparent horny cell which closely embraces the body of the animal is nearly unyielding in its lower two thirds, but terminates above by a flexible portion, which serves to protect the upper part of the body when the whole is expanded, in which state it is of the same diameter as the rest of the cell; but when the animal retracts is folded up and drawn in after it, and completely closes the mouth of the cell.

The flexible part consists of two portions, the lower half being a simple continuation of the rest of the cell; the upper consisting of a row of delicate bristle-shaped processes or setæ, which are arranged parallel with each other round the top of the cell, and are prevented from separating beyond a certain distance by a membrane of excessive tenuity, which surrounds and connects the whole. This mode of termination of the cell is one of constant occurrence, as will be described in other species, and is evidently a provision for allowing of the freest possible motion of the upper part of the body in its expanded state, to which it affords at the same time support and protection.

The mechanism by which the acts of *protrusion* and *retraction* are effected is somewhat complicated, and these acts are usually performed with such rapidity, especially that of retraction, that it was only by perseveringly watching the animals for several hours together, and sketching down each step of the process, whenever I could catch more than a momentary glance of one of them in any intermediate position, that I was at length led to a satisfactory knowledge of the precise mode of performing these operations.

For the process of *retraction* two distinct sets of muscles are provided, the one acting upon the *animal*, and the other upon the flexible part of the *cell*.

The muscles for the retraction of the *animal* are contained in the visceral cavity, and consist of two bundles of delicate thread-like chords (fig. 3. *a* 8 and 9.); the one set (*a* 8.) arising from the bottom of the cell to be inserted about the base of the stomach; the other (*a* 9.) also arising from near the bottom of the cell, though generally at the opposite side from the former, and passing up free by the side of the pharynx to be inserted around the line of junction of this organ with the base of the tentacula. The muscles provided for the retraction of the *operculum*, or flexible portion of the cell, have their origin from the inner surface and near the top of the stiff part, and are inserted into the flexible portion, on which they act. (fig. 3. *b* 2 and 3.) They are most distinctly seen when the flexible operculum is completely drawn in, at which time the latter is folded up, so as to occupy the axis of the upper part of the cell, and to it the muscles are seen extending inwards from the opposite sides of the cell from which they have their origin. They consist of six flattened bundles of fibres having a triradiate arrangement. The *upper three* sets (*b* 2.) act upon the flexible part of the cell and are inserted into it. The *lower three* (*b* 3.) are smaller, and are for the purpose of retracting the bundle of setæ by which it is crowned.

It is at this point that the best opportunity is afforded for investigating the structure of this form of muscle. It would appear as if muscular fibre were here reduced to its simplest condition. The filaments are totally disconnected, and are arranged the one above the other in a single series. They pass straight and parallel from their origin to their insertion, and have a uniform diameter throughout their course, except that each filament generally presents a small knot upon its centre, which is most apparent when it is in a state of contraction, at which time the whole filament also is obviously thicker than when relaxed. The filaments have a watery transparency and smooth surface, and under the highest powers of the microscope present neither an appearance of cross markings nor of a linear arrangement of globules.

These muscles, though apparently attached to the inner walls of the cell, must yet have the membranous parietes of the body interposed between their insertions and these walls, if as I suppose the cell is *completely* lined by the integument. In the lower part the integument is only occasionally seen separate from the walls of the cell, but above it may be easily discerned in the expanded animal passing up to be inserted around the tentacular ring, and thus distinctly bounding this part of the body which is always free within the expanded operculum. It is probable, therefore, that the retractors of the *operculum* as well as those of the *body* are within the *visceral cavity*, and that the relation of the origins of both, with regard to the integument and cell is similar to that which exists in the attachment of the muscles, with reference to the mantle and shell of bivalve Mollusca. This is easily understood if we suppose that the integument in this case, as I have ascertained it to be in another species, is attached to the operculum on a line with the *base* of the setæ, which is the highest point upon which the opercular retractors act, and from which it is there carried up free to the tentacular ring.

This being the *mechanism* by which the retraction of the animal within its cell is effected, I proceed to explain the *mode of its operation*.

The tentacula from being expanded in the form of an inverted cone are brought together into a straight line and immediately begin to descend. Their descent is effected by the contraction of the muscle which passes from the base of the cell to the tentacular ring, (fig. 3. *a* 9.) whilst at the same time the stomach is drawn down by *its* retractor. (3. *a* 8.) The whole body, however, does not descend in a mass, but must be folded up in a somewhat complicated manner, in order that the cell may completely inclose it. For this purpose the œsophagus, surmounted by the tentacula, descends first, whilst the integument of the upper part of the body begins to be *inverted* at the point where it has its insertion around the tentacular ring. As the descent of the tentacula proceeds, the inversion of the integument continues, forming a close sheath around them, (Plate XXI. fig. 12. *c*) until the extremities of the arms have descended to a level with the top of the unyielding portion of the cell. The animal is now completely drawn in, the stomach brought close to the bottom of the cell, and the œsophagus bent in the form of a letter S; the tentacula generally lying straight in the axis of the cell encased in their tegumentary sheath, and so separated from the fluid in the general visceral cavity; the centre of which they have the appearance of occupying, whilst they are in effect external to it. The *animal* being thus retracted, the next step of the process is to draw in the *upper part of the cell* after it. This process, however, always commences before the retraction of the body is completed, and by the time that the end of the arms are on a level with the base of the *setæ*. (fig. 11.) These latter bodies are then immediately brought together in a bundle, and begin to descend apparently by the action of the lower of the two sets of opercular retractors already described. Their descent, like that of the tentacles, takes place exactly in the axis of the upper part of the cell, and is accompanied by an inversion around them of its flexible portion, similar to that of the integument of the body around the tentacula during *their* descent (fig. 10.). Whilst the lower set of muscles are drawing down the *setæ*, the upper set complete the retraction of the *flexible part*, and the whole operculum is thus packed closely in the upper part of the cell, the end of which now presents a triangular indentation, corresponding with the triangular arrangement of the opercular retractors (fig. 3. *b*, and fig. 9.).

In this position of the animal it is impossible to define the whole course of the integument, but when the tentacles are drawn unusually low, (fig. 9.) that portion of it which forms their sheath may be readily seen passing up to the base of the setæ, around which it appears to have an attachment, and to be then continued up the sides of the inverted operculum to the angle at the top of the cell, whence it probably again descends to line the sides of the cell.

Thus the whole process of *retraction* may be easily accounted for, and the office of each set of muscles satisfactorily explained; but the *protrusion* of the animal is effected by a totally different mechanism.

Of course the different *stages* of protrusion occur in the inverse order of those of retraction. The bundle of setæ (fig. 10. *a*) first makes its appearance rising out of the apex of the cell, and followed by the flexible portion (fig. 11. *b*) on which it is set. The tentacula next pass up between the setæ and thrust them asunder, while the integument of the animal is seen gradually rolling outwards from around the tentacles. (fig. 12. *c*.) These latter continue to emerge and the integument to be everted from around them, until the base of the tentacles has risen above the top of the expanded setæ, when the act of protrusion is completed, the tentacula separate and expand, and the cilia commence vibrating*.

During repeated observations of the various steps of the process, I had in vain searched for a set of muscles having an antagonist power to the former and lifting the animal out of its cell. But I could discover no structure of this kind; and indeed it is not easy to imagine how such a mechanism could act, since the upper flexible portion of the sheath could afford no fixed point of attachment for elevating muscles, whilst from the want of rigidity in the body, and the manner in which it is folded up in its cell, no muscles arising from a lower point could effect its expansion.

After examining several species for an explanation of this phænomenon, I at length obtained a clue to it from one more favourable for examination than the rest. (Plate XXIV. fig. 3. *a*.)

In this species the body is capable of protruding for some distance beyond the mouth of the cell, in which state its delicate membranous walls may be readily traced downwards on one side to nearly the bottom of the cell, (Plate XXIV. fig. 3. *a* 3.) from the inner surface of which they are capable of being separated in about one third of its circumference and from top to bottom of the cell, but remaining apparently in immediate connexion with the other two thirds.

This separation of a portion of the parietes of the body from the inner surface of the cell, I found invariably to accompany the protrusion of the animal; and on examining further, I discovered upon this part of the body two rows of delicate, short, transverse filaments, arranged at a little distance from, and parallel to, each other. (*a b* and *d* 3.) These fibres were distinctly seen to contract whenever the protrusion of the animal took place, and to become relaxed again upon its retiring into its cell; the walls of the latter being so pellucid that the minutest alteration in the form of these muscles was readily seen. When contracted to their utmost, each filament was reduced to just half its original length, at the same time that its thickness was doubled, and the little knot upon its centre appeared also somewhat thickened. (Plate XXIV. fig. 4 and 5.) During their contraction, the unattached part of the pa-

* Figs. 9, 10, 11, 12, represent the different stages of protrusion and retraction in the order in which they occur.

rietes upon which they were arranged was seen to recede from the inner surface of the cell, and to be drawn into longitudinal lines, especially at their points of origin and insertion. When the animal retired they returned to their former dimensions. These parietal muscles, which in structure exactly resemble the retractors, I have observed in every species of ciliated polype that has since come under my notice, and have ascertained its existence in Bowerbankia. (Plate XXI. fig. 13.)

These transverse filaments then, acting together from top to bottom of the space upon which they are arranged, must necessarily tend by their contraction to diminish considerably the *diameter* of the visceral cavity, and will therefore exercise a pressure upon the fluid which it contains. The effect of this will be to elongate the body in the direction in which it is most free to move, and it might be supposed that this would satisfactorily account for the act of protrusion; but it must be remembered that the contents of the cavity are folded up in a complicated manner, and the cell closed by its operculum, the whole of which parts have to be unfolded in regular order before the act of expansion is completed. I doubt, therefore, whether this simple apparatus could accomplish this act unassisted; but I believe it to be materially aided by the cooperation of the alimentary canal, which undoubtedly has the power of straightening itself from the sigmoid flexure into which it is thrown when the animal is retracted. I am led to think this from having frequently observed the great extent of motion which the upper part, especially of the alimentary canal, is capable of exercising, independently of any action of the muscles attached to it; and from having also noticed occasionally that, during the rising of the tentacula, the unfolding of the integument from around them seemed rather to follow as the consequence of their advance, than as being the means of effecting it, which cannot well be explained, if we suppose the fluid of the body to be driven upwards by the contraction of the parietal muscles with sufficient force of itself to expand the upper part of the body, and so to carry up the alimentary canal and to thrust out the arms. And this appears the more probable when we observe that even in the simple hydriform polypes, the advance and receding of the animal in its cell is entirely effected by the action of the parietes of the body, which are analogous to the alimentary canal in the present case; the hydriform polypes possessing no distinct muscles to assist in these operations.

To return then to Bowerbankia. Let us see how far these considerations will apply to the explanation of the phænomenon in question. The animal being retracted, with the stomach resting upon the bottom of the cell, begins to erect itself by straightening the alimentary canal; and the tentacula must be the parts first to rise. Before, however, these can protrude from the cell it is necessary that the flexible operculum which closes the mouth of it should be unfolded. As there does not appear to be any separate apparatus for this purpose, and as I have never observed it to occur independently of the motions of the animal, it may be presumed that this is effected by the pressure from below when the animal endeavours to rise.

Thus the tentacles rising first would press up the little bundle of setæ (Plate XXI. fig. 10. *a*.), that lies immediately above them. The pressure continuing, the flexible part of the sheath (fig. 11. *b*.) would be next unfolded, and the whole would then be expanded by the passage of the several parts in succession through them. (fig. 12.)

It is now that the parietal muscles come chiefly into play, and by keeping the teguments tense during the alteration in the position and form of the body, prevent any collapsing of its parietes, which might entangle the operation of any of its parts, and which, for the want of this provision, would be likely to ensue from the pressure of the surrounding fluid when the animal rises from its cell; especially as there does not appear to be that ready communication between the interspace then left in the cell and the surrounding element, by which the water might flow in to supply the vacuum left by the change in the form of the lower part of the body, during the protrusion of the animal. This circumstance I had occasion to prove by noticing the forcible indentation of the stiff horny cell itself, by the pressure of the surrounding fluid, which in some instances followed this act, as is represented in *Lagenella repens* (Plate XXIV. fig. 2. *a*.). Further, by the contraction of these muscles the body may be so much elongated as to carry the base of the arms to some distance above the margin of the cell, by which the freedom of their action is considerably increased, the stomach, being then lifted from the bottom of the cell, hanging suspended in the visceral cavity. It would appear then that the act of *protrusion* is effected by the combined operation of the parietal muscles and of the alimentary canal, which in fact forms the principal part of the substance of the animal, the parietes being purely membranous, and having little else to do than to retain the fluid in which the viscera float.

It is interesting to compare these parietal muscles with similar parts in animals of another class. Having been frequently struck with the close analogy which the general characters of the animal under consideration presents with those of the class *Rotifera*, especially in the character of the *retractor muscles*, I was led to compare the *parietal muscles* also with the parts which, in *Hydatina senta*, for example, are usually considered and represented as the dorsal vessel with its lateral branches. (For it must be understood that the parietal muscles of which I am speaking have no resemblance to the circular fibres that surround the bodies of vermiform animals, and are intimately blended with their integument, but have a totally different character, being simple short filaments, occupying a very small portion only of the circumference of the body, and being apparently connected with the parietes only by their extreme points of attachment). Having procured therefore some specimens of Hydatina, I was not much surprised to find that the parts in the two animals were identical; the transverse lines of Hydatina being obviously *parietal muscles*, which whenever the body becomes elongated may be observed by their contraction to draw that side to which they are attached into longitudinal folds, and to be again elongated whenever the body is shortened by the contraction of the longitudinal muscles, to which the former are evidently the antagonists. In this case the alimentary canal being straight and not folded on itself, and the body being unshackled by a dense covering, the parietal muscles alone are adequate to effect its expansion.

Upon a review then of this description of the organization of Bowerbankia, it must be admitted that the mechanical functions are executed with a degree of perfection, which in a being so exceedingly minute cannot fail to excite our surprise and admiration: not less interesting either is it to observe the more vital operations of this highly organized species.

The little animal, when in full vigour, is seen projecting from its cell with the arms extended and the cilia in full operation, the upper part of the body being frequently turned from side to side over the edge of the cell, the extremity of which, from its peculiar flexibility, moves along with it. The particles, carried to the mouth in the vortex produced by the action of the cilia, after remaining a little while in the pharynx, are swallowed by a vigorous contraction of its parietes, and carried rapidly down the œsophagus and through the cardia to the gizzard, which expands to receive them. Here they are submitted to a sort of crushing operation, the parietes of the organ contracting firmly upon them, and the two dark bodies being brought into apposition. Their residence, however, in this cavity is only momentary, and they are immediately propelled into the true stomach below, where they become mixed up with its contents, which during digestion are always of a dark rich brown colour, being tinged by the secretion of its parietal follicles.

The food appears to be retained for a considerable time in the stomach, and may be frequently seen to be regurgitated into the gizzard, whence, after having been again submitted to its operations, it is returned to the stomach. Here it is rolled about by the contraction of its parietes, and at its upper part is frequently submitted to a rotating motion. This rotation of particles is chiefly near the pyloric orifice, and a mass may be frequently seen projecting through the pylorus into the intestine, and rotating rapidly in the direction of the axis of the orifice. In an animal having a similar form of pylorus to this, but in which the parts were more transparent, I could distinctly see the cilia by which this rotation is effected surrounding the orifice.

The granular matter, after rotating for some time at the pylorus (a provision for preventing its too rapid escape from the stomach), passes into the intestine, where it accumulates in little pellets, that distend the parietes of the tube; and it is possible that it may be here still further acted upon by these parietes, which have a spotted appearance.

By the contraction of the intestine the little pellets of excrementitious matter are carried rapidly upwards to the anal orifice, which is seen to open, and the little pellet to be tilted over its edge, when it is immediately whirled away from the sight in the current produced by the ciliated tentacles, and the orifice of the tube again contracts.

With regard to the mode in which the animals are united together, I could not discover that any connection existed between them beyond that which results from their cells being placed upon a common stock. In almost every case, however, I could see a filament (possibly a tube) passing down from the base of the stomach into the short neck that connects the cell with the main stem, but beyond this I could not trace it. It appeared to be distinct from the retractor muscles, by which it was surrounded. The stem itself appears to be nearly homogeneous throughout, and no motion of particles was ever observed in its interior. Each cell is capable of a slight degree of flexion upon the main stem, but the means by which that is effected are not obvious.

The only mode of *reproduction* that I had the opportunity of witnessing was that by a process of gemmation from the common stock, or creeping stem, from which the young animals in various stages of growth were seen sprouting (Plate XX. fig. 2.).

The smallest gemmæ appeared to be homogeneous in texture, forming little nodules on the parent stem. Those further advanced were seen to present something like a boundary line, indicating the thickness of the parietes of the future cell. Within this, in others, was a little dark mass, which in larger ones presented a rough outline of the form of the complete animal. Those about half grown had all the parts distinctly traced out; the retractor muscles completely formed; the tentacles short and clumsy; the walls of the alimentary canal thick, and its cavity clearly defined, as well as the dark spots in the gizzard (fig. 3. *c* 1.). These were commonly seen in all stages of growth up to full maturity, grouped together on the same stem without any order, the stem terminating in a blunt growing end.

As I shall have occasion to notice in another part of this paper the second mode of reproduction in this class, namely, that by locomotive ciliated gemmules, but which I did not observe in the present species, I defer for the present the consideration of this subject. I cannot, however, avoid referring here to an appearance which I have commonly observed, that seems to be in some way connected with it. It is that of one or more rounded or oval bodies, of a brown colour, lying apparently loose within the visceral cavity, and near the bottom of the cell (Plate XXI. fig. 14 and 15.). From their dark colour they are generally very conspicuous, especially as they remain in the cells long after the animal has perished and disappeared from them. From this circumstance it might be imagined, that they resulted from decomposition, were they not also frequently seen in the living animal. Moreover they have a definite form and size, and when removed from the cell and carefully examined are found to consist of a delicate transparent membrane, inclosing a brown granular matter to which their colour is due. (fig. 16.) It is further remarkable that they are often seen as large in animals not even half matured as in the adults (compare figs. 14 and 15.). Besides these I have sometimes noticed other bodies more nearly spherical, and of a milk-white colour, which when pressed, broke up into minute granules. I have observed as many as three of the white and two of the brown bodies in the same animal, (fig. 14.) but the former are seldom seen. The brown bodies, however, are so extremely common, that I have seldom had occasion to examine any species of this class without detecting them. I have not, however, been able to ascertain their use.

They do not appear to answer any purpose in the economy of the animal; and from their persistence after its death, they would seem to have the power of resisting those forces which cause the decomposition of the other parts. It is most probable that they are connected with the process of reproduction, but whether they may be viewed as ovaries or as immature ova, and what relation the white and brown bodies have to each other, are considerations that might be reserved for further opportunities of elucidation. I have never detected any motion in the granules of which they are composed.

PLATE XXII.

Vesicularia spinosa, Thompson, Zool. Research. Mem. V. pl. iii.
Syn. *Corallina confervoides*, Ellis, Cor. pl. xi. N. 17. b. B. C. D.
Sertularia sericea, Pall., El. Zooph. p. 114. No. 65.
Sertularia spinosa, Linn., Gmel. p. 3855. No. 23.
Valkeria spinosa, Flem. Brit. Anim. p. 551. Gen. lxx. 198.

This species forms part of the subject of Mr. Thompson's memoir, whose name for it I have adopted. In this memoir, which contains but a very rough sketch of the animal, he calls the part that I have described as a gizzard the stomach, which latter organ he mistook for an ovarium.

It might be difficult to select two species differing more in external characters than do this and the previous one, yet in the structure of the *animal* hardly any essential points of distinction can be observed: it is one of the smallest and most delicate species on our coast. The main stem, which is zig-zag, (fig. 1.) sends from each angle two branches that divide dichotomously to their extremities, which in *growing* branches are rounded, but in others sharp and spiny; a circumstance that did not escape the notice of Ellis. The vesicles are so minute that they can with difficulty be detected by the naked eye. The animal has but *eight arms*, (fig. 3.) which are short and stiff, and during expansion remain nearly motionless in the usual funnel-like form, but may be occasionally seen separated so far from each other as to stand out at nearly right angles from the body: they are ciliated, but not armed with spines. The alimentary canal presents the same character as that already described in Bowerbankia; but allowing for the much smaller size of the animal, is proportionately shorter and stouter.

The muscular apparatus consists of the gastric and tentacular retractors, the former (fig. 8. *a.*) arising from the bottom, the latter, (8. *b.*) a little above from the side of the cell; two rows of parietal muscles (fig. 8. *c.*), and *two* sets of operculum retractors (fig. 8. *d.*), in which respect it differs from the former species, where there are *three* double sets; and the triangular indentation at the upper part of the closed cell is consequently wanting. The cell is also much broader in proportion to its length, having a more oval form. The operculum is finished by a row of setæ. The connecting stem has a remarkably definite character (fig. 2.). Between every dichotomous division is a joint bearing three cells, which, when they drop off leave a circular foramen. The cells are strictly unilateral upon the stem, and diminish in size very regularly towards the growing extremity; the last few being mere buds from its surface. Within the stem may be seen a number of transparent, circular bodies of a tolerably uniform size, that appear to be attached to the inner surface. They very much resemble in appearance the granules which may be seen through the cell attached to the membranous parietes of the animal itself. These latter are smaller than those in the stem, and more scattered. I have not ascertained the use of either.

Ellis was, I believe, the first to notice in this species what appears to be a direct medium of communication between the animals themselves. It consists of a thread of a darker substance than the rest of the stem, running within its upper surface immediately below the base of the cells. Ellis states* that the slightest movements of the animals were communicated to this substance, an observation that I have not been able to confirm; but my specimens were not very lively. The point is one of interest and worthy of further investigation.

PLATE XXIII.

Valkeria cuscuta, Flem., Brit. Anim. p. 550. gen. lxx. 196.

Syn. *Corallina cuscutæ forma*, Ellis, Corall. N. 26. pl. xiv. c. C.

Sertularia cuscuta, Linn., Gmel. p. 3852. No. 18. and Muller, Zool. Dan. 3. p. 62. t. 117. f. 1—3.

Cuscutaria cuscuta, Blainv. Dict. des Scien. Nat. p. 461.

Vesicularia cuscuta, Thomp. Zool. Research. N. IV. pl. ii. 1.

This is the most minute species that I have met with. Its creeping stems are found closely adherent to the filamentous ramifications of a species of Ceramium, on which it grows parasitic, with much of the habit of Dodder, whence its trivial name (fig. 1. and 2.).

It has been placed in the same genus with the species last described, but differs from it, and also from Bowerbankia, in the entire absence of the manducatory organ; a difference which it is of great importance to observe with reference to a natural arrangement of the class†.

The ciliated tentacles are eight in number, slender, and often widely spread, exhibiting a good view of the oral aperture (fig. 4. *a*.).

The alimentary canal is here of some length, and acquires a considerable sigmoid flexure when the animal is at rest (fig. 5.). The intestine near its termination possesses a decided rectal enlargement, which is very distinct even when empty (fig. 5. *e*.).

* Essai sur l'Hist. Nat. des Corall. p. 36.

† I have for this reason removed it from Vesicularia, and adopted the name previously given to it by Dr. Fleming.

There appears to be but one set of parietal muscles in this instance. The retractors of the body resemble those of Bowerbankia, as do also those of the operculum in their division into an upper and a lower set, but there appear to be only two instead of three of each, as in Bowerbankia (fig. 4. *b.*).

The granules which adhere to the parietes are very distinct in this species, and remain attached to the inner walls of the cell, after the rest of the animal has disappeared (fig. 4. *c.*), together with the brown bodies which I have conjectured to be ovaries or ova. I have not generally observed more than one of these bodies in each animal of this species.

A very remarkable agitation of particles, which was frequently observed in the visceral cavity, and very closely resembled the irregular vibration of cilia, was found, by the aid of a very high power, to be caused by a multitude of minute *cercariæ* (fig. 5.) swimming about with the greatest activity in the fluid with which that cavity is filled. When this cavity was laid open by a needle they escaped and swam away by the serpentine motion of their bodies. They consisted simply of a long slender filament, with a rounded extremity, by which they occasionally fixed themselves (fig. 5. *g.*). Similar parasites were not unfrequently observed in other species.

The cell is terminated by the usual row of setæ (fig. 5. *f.* and fig. 6.). From the quantity of earthy material combined with its horny texture, it is rendered so opake as to present great difficulty in the examination of the contained parts. This character, which pervades the stem also, renders these parts exceedingly tough and strong; and notwithstanding its extreme fineness the stem will bear the exertion of a considerable degree of force without breaking. When these parts are pressed by the dissecting needle they yield a grating sound.

The arrangement of the cells with regard to the stem is intermediate in regularity between that of the two former species. They are generally gathered in clusters which surround the stem (fig. 3. *a.*); the cluster nearest to the growing extremity having its cells gradually diminishing in size, and more obviously springing from opposite sides of the base of support, the long spiny end of which often projects in a remarkable manner beyond the extremity of the branch upon which it creeps. The stem is often seen divided into joints at irregular distances, and the cells are sometimes set on short branches springing from them (fig. 3. *b.*).

PLATE XXIV.

Lagenella repens, Mihi.

Fig. 1. and 2. Parasitic, with a creeping stem, on *Sertularia* and on *Halodactylus diaphanus*. Not very common.

This species has twelve ciliated arms (fig. 3. *a.*), not spiny. The alimentary canal is short and stout, and whilst the animal is expanded remains high up in the body. During retraction the stomach is never brought down to the bottom of the cell, but remains suspended from the upper part of it by the intestine, which appears to have some attachment at this point. The upper part of the tube, however, is generally brought down lower than the stomach, in order that the tentacles may be completely drawn in (fig. 3. *c*.). By this suspension of the stomach from the upper part of the cell a fixed point is obtained, from which the retracted flexed portion of the tube may erect itself with the same effect as if the stomach were in contact with the bottom of the cell. This is a point which it would be important to observe in generic distinctions; but here, as with many other points in this species, my observations were not carried to the extent that they have been in others, as this was one of the specimens with which my investigations were commenced, and I have never since had an opportunity of confirming them. This is the more to be regretted, as from the complete isolation of the cells, and the extreme transparency of their parietes, a clearer view of their contents is obtained than in any species that I have subsequently met with.

The spots upon the pharynx, and their absence in the triangular ciliated space, were remarkably distinct (fig. 3. *a* 1.), as was also the difference between the dark brown colour of the hepatic follicles in the *replenished* stomachs, and their pale and almost inconspicuous character in the *empty* ones. (Compare *a* and *b*. fig. 3.) The position of the cardia was not ascertained. When the body was turned so that the pylorus was presented to view, and this happened to be empty, a row of cilia were distinctly seen surrounding it. The vibration of these cilia, as well as of others which were observed in the stomach, appeared to be entirely under the control of the animal. Their action was frequently observed to be suddenly suspended, when the rotation of particles ceased also, and when it recommenced the motion of particles was renewed. This rotation was often so rapid at the pylorus that I should think from one to two hundred revolutions must have been performed in the minute. When very small animalcules were introduced into the bulging pharynx, several convulsive efforts were sometimes made before they could be swallowed; during these the animalcules not unfrequently escaped again by the mouth, but were intercepted by one of the tentacula being bent forward and striking the animalcule as it rose with a sharp blow that drove it back again into the pharynx. The animalcules did not immediately perish in the stomach, but continued their motions for some time after being introduced into it.

The gastric and tentacular retractors are particularly distinct, and have the usual origins and insertions (fig. 3. *d* 1 and 2.). The double row of parietal muscles (fig. 3. *d* 3.) have been already described in the notes on the species first quoted. There appears to be but one set of retractors of the operculum (fig. 3. *d* 4.), which is generally drawn towards the side of the cell from which they arise, leaving a slight indentation in the top of the latter when retracted (fig. 3. *c*.). The granules on the parietes are less numerous than in most instances, but very conspicuous.

The cells have an oblong form, and are connected to their narrow creeping stem by a short peduncle. The opercular portion terminates in a notched margin, and is very short (fig. 3. *a* 4.). (It is possible that this notched margin may be formed by the extremities of short and broad setæ, but this was not determined.) The cells spring from the sides and upper surface of the stem, and turn upwards as in *Bowerbankia*. They are set at some distance apart.

The gemmæ exhibit the same process of growth as in other cases, and are scattered irregularly amongst the larger cells (fig. 3.).

PLATE XXV. and XXVI.

Halodactylus diaphanus, Mihi*.

Syn. *Alcyonium seu Fucus nodosus et spongiosus*, Ellis, Cor., p. 102. pl. xxxii. fig. d. D.

Alcyonium gelatinosum, Linn., Gmel., p. 3814. No. 11. Lamx. Polyp. flex., p. 350. No. 495. Mull. Zool. Dan. iv. p. 30. t. cxlvii. f. 1—4. Flem. Brit. Anim. p. 517. gen. xl. 86.

Alcyonidium diaphanum, Lamx. Gen. Thalass. p. 71. t. 7. f. 4. Hooker, Flora Scotica, part II. p. 75. London Encyc. of Plants, 1829, p. 928.

Ulva diaphana, Hudson, Flor. Angl., vol. iii. p. 570. Sowerb. Engl. Bot. t. 263.

Extremely common on the Sheppy coast, especially after a gale, when it is cast up in immense quantities, and is found attached to loose stones and shells, in the form of soft, flexible, finger-like processes of very irregular figure, being rounded and smooth upon the surface, or flattened, nodulated and branched, sometimes attaining the length of two or three feet, but generally about six inches long. The animals are, however, so small that such specimens must contain many millions of them. When a portion of this is placed in a trough of sea-water, the little animals are seen quickly to emerge in such numbers as to cover its surface with a coating as it were of the finest down; and they are so closely set that there seems to be hardly room for their several operations (fig. 1.). In this state it is scarcely possible to make any observations upon them, but when a few only are projecting they become from their extreme delicacy and transparency peculiarly favourable subjects for examination. On this account, and also from the length of time that they may be kept in vigour, I have been enabled to prosecute the inquiry further than other specimens enabled me to do.

Plate XXVI. fig. 7. The tentacula are sixteen in number, (occasionally fifteen)† fully two-thirds the length of the body of the animal, and extremely slender and

* ἅλς et δάκτυλος. The confusion and doubt which have so long pervaded the very ill-defined genera *Alcyonium* and *Alcyonidium* appear likely to be dispelled only by beginning *de novo*, and adopting a new name in conjunction with characters sufficiently definite to preclude all probability of further error. I have therefore renamed the present species as indicative of a new genus, with which other species will probably be found, upon a minute examination of their intimate structure, to possess congeneric affinities.

† Fleming, Lamouroux and others appear to be in error in stating them to be twelve.

flexible. When expanded they are frequently seen to roll up closely upon themselves, (fig. 18.) even down to their base, the revolution taking place either inwardly or outwardly, and in one or more arms at the same time. Their full expansion affords a more perfect campanulate form than is usually met with in this class, each of the arms having a slight curve outwards towards its extremity, which gives to the whole a very elegant appearance. It is remarkable that in some specimens the arms are much shorter on one side of the body than on the other. In many positions this is not very striking, as it might be attributed to an appearance of fore-shortening of that side which happens to be turned towards the observer, (fig. 17.) but when viewed laterally this character is very obvious (fig. 16.). The arms when viewed with an amplifying power of 200 linear are seen to be tubular throughout, (fig. 19. *a*.), and to have an aperture at each extremity. The aperture at the apex is extremely small, and in a lateral view sometimes appears like a slight notch at the extremity of the arm. The apertures at the base are seen more plainly, and are situated in the centre of the tentacular ring, one corresponding with the base of each arm (fig. 8.). I have also sometimes observed what would seem to be a fine canal, running round in the substance of the ring, and apparently uniting the tentacular canals (fig. 10.). It would be exceedingly interesting to ascertain with what parts these tentacular canals communicate. As the tentacles appear to be respiratory as well as prehensile organs, it is most probable that the canals by which they are permeated are for the purpose of allowing a circulation of fluid through them; but from the minuteness of the parts and the agitation of the surrounding medium by the rapid action of their cilia, it would be a matter of great nicety to detect such currents though they should exist.

The action of the tentacular cilia appears entirely under the control of the animal, and they are sometimes seen completely at rest. If, however, a portion of one of the arms be cut off, the action of the cilia continues as vigorous as before, and the isolated part is carried about in the field of the microscope. When the animal is dead, these cilia are seen to be longer and considerably more numerous than they appeared to be when in action (fig. 19. *a*.). As the parts gradually perish the cilia disappear, and the surface of the arms becomes covered with a granular matter and the part shrinks to a mere thread (fig. 19. *b* and *c*.).

The ring upon which the tentacles are set is well marked, and terminates on its inner circumference by a sharp edge projecting to form the mouth of the pharynx. It is probable that this tentacular ring never contracts except to bring the base of the tentacles together. But whilst it remains fixed so as not to alter the arrangement of the arms, the closing of the mouth of the pharynx is effected by the constriction of the parts immediately below it, which there appear as if they had been bound round with a ligature (fig. 8. *d*.).

The pharynx (figs. 7, 8 and 9.) is very short in this species, and its parietes are covered by the peculiar spots already noticed, except in the triangular space at the upper part (fig. 9. *c*.) which is entirely free from them, and where a vibration of cilia may be occasionally detected. On the opposite side, generally, of the pharynx, may be seen a line (figs. 8 and 9. *a*.) running down to the cardia, and if this part be observed for a short time it will be seen that the pharynx is repeatedly distended, as by a sudden act of insufflation, and that whenever this distention takes place the part bounded by the line becomes expanded but quickly returns to its former position. It is probable that there is here a muscular apparatus by which these sudden expansions of the pharynx are effected. When at rest this part has much the appearance of a tube, which is marked by rough cross lines, and wants the spotted character of the surrounding parts (fig. 9.).

This sudden expansion of the parietes of the pharynx, which takes place at irregular intervals, appears to be connected with the act of *respiration* as well as of *nutrition*; for not only are the particles of food thus admitted more freely into the sac, but the water is more readily renewed and brought more effectually into contact with its inner surface.

With a view of determining to what extent the flow of water into the pharynx took place, some particles of carmine were diffused through the fluid in which the animals were placed. As soon as the cilia commenced vibrating, the particles of carmine were put into rapid motion, (fig. 7.) being carried in a stream down the inner surface of each arm, the greater part passing out again between their bases; while of the remainder part turned upwards again and issued from the centre of the expanded arms, (a course best seen when the arms were turned forward) and a few were carried through the mouth into the pharynx, where they were submitted to a rotatory motion by the action of the cilia lining its upper part; and after remaining there a short time some were swallowed, while the rest escaped at the mouth, and their place was supplied by others. From this experiment it did not appear that the flow of fluid into the pharynx was so free as might be expected, seeing that the mouth is almost constantly open; for except during the act of expansion, by which the sac is suddenly filled with water, the parietes are so nearly in contact as to obliterate a large portion of its cavity: at every expansion, however, the greater part of the water must be renewed.

The *size* of the particles which the animal swallows appears to be regulated conjointly by the mouth and tentacula. The aperture within the tentacular ring, which forms the mouth of the pharynx, is not capable of distention like the mouth of Hydra; for if this part were to be engaged in swallowing large prey, the whole tentacular apparatus would be thrown into disorder, and the regular flow of fluid to the pharynx interrupted. Whilst, therefore, the diameter of the mouth prevents the admission of the larger particles, the size of the smaller ones will be regulated by the spaces between the tentacula, which, like a sieve, of a degree of fineness proportioned to the number of the arms and the consequent width of their intermediate spaces, would allow all the finest particles to drain away, and retain in their area only those of an intermediate size. These readily flowing into the pharynx become subject to a selection of a less mechanical nature, in accordance with which some are swallowed and others rejected. In the act of swallowing the mouth is closed by the constriction below the tentacular ring, and the sides of the pharynx being brought into apposition, principally by the action of the part already alluded to, the particles are forced through the cardia, which projects into the pharynx with a nipple-like prominence (fig. 8. *b*.).

As all below this point appears to be concerned more or less in the office of digestion, the stomach may be considered as commencing here, though in form it might rather resemble an œsophagus. The hepatic follicles, however, reach nearly as high as the cardia (fig. 7. *a*.). If then the cardia be taken as the line of demarkation between the pharynx or œsophagus and the stomach, without regard to its variable position in different species, then it will be found that in some the pharynx is short and the stomach very long, as in the present instance, and in *Valkeria cuscuta*; whereas in *Bowerbankia*, where the cardia is low down, the reverse obtains, and the pharynx is of great length, while the stomach is comparatively short.

Those who would follow out the analogy which undoubtedly exists between these animals and those of the class *Tunicata*, and would compare the *pharynx* in the present case to the *respiratory sac* in *Ascidia*, might contend that the *upper* aperture of the pharynx being analogous to the entrance to the respiratory sac in *Ascidia*, then the *lower* aperture should be called the mouth, as being placed at the bottom of the sac. As, however, the pharynx is here *certainly* an organ for the reception and deglutition of food, and only *probably* concerned in respiration; it would be more consistent to use the names as I have applied them; the upper and lower apertures being respectively *mouth* and *cardia*, while the intermediate space may be designated from its probably double function, *respiratory pharynx*. The distinction, if contended for, would be at best but one of names and could not improve the analogy.

The stomach is not furnished with a gizzard in this species. The intestine forms a considerable elbow at its origin, and is short and wide, terminating not as in other cases near the tentacular ring, but about midway up the body, at a point opposite the base of the setæ (fig. 7. *a*.).

A very singular organ (figs. 16, 17 and 18. *b*.) was frequently observed consisting of a little flask-shaped body situated between the base of two of the arms, and attached to the tentacular ring by a short peduncle. The cavity in its interior is lined with cilia which vibrate downwards towards the outer, and upwards towards the inner side; it has an arrow neck and a wide mouth, around which a row of delicate cilia are constantly playing. No flow of fluids could ever be detected through it, nor did the use of carmine assist in showing with what parts the cavity in its interior might communicate. From the circumstance that it is more frequently absent than present, it cannot be an organ of vital importance to the animal: and it is too intimately blended with the sides of the tentacula and too constant in its position to be regarded as a parasite. Does it indicate a difference of sex?

The peculiar fleshy character which caused the name *gelatinosum* to be applied to this species arises from the mode in which the cells are united together. Their arrangement is best seen by making a thin *transverse* slice of the main substance and examining it with a low power (Plate XXV. fig. 3.). The cells are then found to be arranged parallel with one another and having their sides united together so as to form a compact ring, of which the bases constitute the inner and the apices the outer circumference. The centre of the cylinder, of which this is a section, is occupied by a light cellular tissue and a clear fluid, probably water. In such a section similar brown bodies to those already described are seen in great numbers, and not confined to the cells, but dispersed through the whole substance. The arrangement of the cells being thus shown, a more accurate view of their structure is obtained by examining a thin section made *parallel with the surface* (fig. 4.). In this view their ends only are seen having an hexagonal form, from their pressure upon each other, but in each compartment the animal may be discerned with all its parts. Sometimes, however, the cells, instead of being arranged parallel to one another, lie so obliquely, that their sides instead of their apices form the outer surface; an arrangement which bears a close resemblance to that of the cells of *Flustra* (fig. 5.). But in order to witness the different stages of protrusion and retraction a portion of the mass must be viewed edgewise (Plate XXV. fig. 2. and Plate XXVI. fig. 7.). In which position, although the lower part of the cell and animal is generally concealed from view, all the most interesting parts may be observed as they rise in succession above the surface. The stages of protrusion and retraction occur in the same order and with nearly the same phenomena as in *Bowerbankia*. (See the series from fig. 11 to 16. Plate XXVI.) The arms, however, instead of rising straight are often seen bent upon themselves, a provision that appears to be necessary, on account of the great length of some of them, in order that they may be completely inclosed in the cell.

The upper portion of the cell, from its superior transparency and flexibility, appears to contain little, if any, earthy matter. The setæ (fig. 7. *a* and *d*.) are very stout and short, broad at their base, and few in number. The body projects to an unusual distance beyond the mouth of the cell (fig. 7. *a*.), and its delicate parietes may be seen separate from the whole circumference of the cell, except where they are attached to the edge of the operculum at the point whence the setæ arise.

Cercariæ were seen in the bodies of these animals which did not differ in any respect from those of *Valkeria*, and occupied a similar position. On one occasion these were observed drifting rapidly to the upper part of the visceral cavity, and shortly after issued from the centre of the tentacula; but as the animal had in the mean time half withdrawn itself, I lost the opportunity of tracing their course. It would appear from this that there is some external communication with the *cavity* of the body.

The process of reproduction by gemmation (in this case by the growth of young animals and cells amongst the mature ones) may be seen in every specimen (Plate XXV. fig. 4.). The smaller cells are triangular, and the animal forms a mere spot in its centre. As they grow they thrust aside the surrounding cells, and the number of their sides increases until they acquire the irregular hexagonal form of the adult. In the oblique position of the cells (in which they look like a new growth encrusting the old mass like a *Flustra*) the young cells are less angular, and arranged more regularly at the spreading edge (fig. 5.).

This species afforded an opportunity of examining also the reproductive *gemmules*. These are readily seen in spring as minute whitish points just below the surface of the mass (fig. 3. *a a*.). Sometimes they are of a darker colour, and exceedingly numerous, appearing to occupy almost the whole substance. If one of these points be carefully turned out with a needle it is found to consist of a transparent sac (fig. 20. *a*.), in which are contained generally from four to six of the gemmules, which, as soon as the sac is torn, escape and swim about with the greatest activity, affording a most interesting subject for microscopic investigation.

When viewed with a power of forty, linear measure, they are seen to be of an oval or rounded form (fig. 20. *b* and *c*.), convex above, and nearly plane below, and fringed at the margin with a single row of cilia, which appear to vibrate in succession round the whole circumference. Under an amplification of 120 they assume a different aspect (fig. 21. and 22.), and their minute structure is clearly discerned. Viewed as opake objects, both the body and cilia have a silvery whiteness, but by transmitted light the former appears of a dark brown, and the cilia of a golden yellow colour. Upon the most convex part of the body, which is not generally in the centre, but leaning to one side, are set from three to five prominent transparent bosses surrounded by a circle; and other circles are seen extending to the base of the body, the extreme margin of which is bounded by a row of prominent tubercles. These marginal tubercles are from thirty to forty in number, and from the circumstance of the cilia arising from them, it is probable that they are for the purpose of governing their motions, and therefore analogous to the muscular lobes of *Hydatina senta*. No structure, however, could be detected in these, nor in any other part of the body beyond a mere granular parenchyma.

Fig. 22. Under this power the whole character of the ciliary motion is changed, and it is seen that what before appeared to be a single cilium is in fact a wave of cilia, and that their motion, instead of being in the direction of the circumference of the disc, is at right angles to this. The ciliary phenomena are the most readily observed when the gemmule is nearly at rest, or has become languid; it then lies either with the convex or the plane side uppermost, and with the cilia, which are of great length, doubled in the middle upon themselves (fig. 21.), so that their extremities are brought back nearly to touch the margin of the disc from which they arise. The whole fringe of cilia is then suddenly unfolded, and after waving up and down with a fanning motion they are either again folded up towards the under surface of the body, or they commence their peculiar action. As the cilia have the appearance of moving in waves round the disc (fig. 22.), each wave may be thus analysed. From a

dozen to twenty cilia are concerned in the production of each apparent wave, the highest point of which is formed by a cilium extended to its full length, and the lowest point between every two waves by one folded down completely upon itself, the intervening space being completed by others in every degree of extension, so as to present something of the outline of a cone. (And it is remarkable that one of these corresponds very nearly in breadth with one of the supposed muscular lobes.) As, however, the persistence of each cilium in any one of these positions is only of the shortest possible duration, and each takes up in regular succession the action of the adjoining one, so that cilium, which by being completely folded up formed the lowest point between any two waves, now in its turn by its complete extension forms the highest point of a wave; and thus while the cilia are alternately bending and unbending themselves, each in regular succession after the other, the *waves* only travel onward, whilst the *cilia* never change their position in this direction, having in fact no lateral motion. When the waves travel very rapidly they appear smooth on one side and fringed on the other (fig. 23.). The whole of the ciliary motions are so evidently under the entire control of the animal as to leave not the slightest doubt in the mind of the observer as to this point. The whole fringe of cilia may be instantly set in motion, and as instantaneously stopped, and their action regulated to every degree of rapidity. Sometimes one or two only of the waves are seen continuing their action whilst the remainder are at rest, or isolated cilia may be observed slowly bending and unbending themselves, or projecting entirely at rest (fig. 21.). The body is generally somewhat pointed towards one extremity of the oval, and at this part may be observed a bundle of cilia, longer than the rest, and moving very rapidly (fig. 21. *a*.). Their vibrations were in several instances counted very evenly at 230 times in the minute, continuing in action whilst all the others were folded up. These may be respiratory, whilst the others are chiefly locomotive. There can be little doubt that this explanation of the action of the cilia in the gemmules is applicable also to those of the tentacula of the adult animal, and not only in this species but throughout the class generally; for I have already observed that the tentacular cilia are infinitely more numerous when at rest than they *appear* to be in action: and I have also noticed, when their motions become languid, that here also they vibrate, not in the direction of the plane of the arms, but at right angles to it, and with the same hook-like form as in the gemmules. In this way the apparent travelling of the cilia up one side of the arm and down the other, as the eye is seduced to follow the waves which they seem to produce, is at once explained.

It would be impossible to explain the variety of motions which the gemmules are capable of executing, were it not obvious how complete is their control over the action of the cilia, which are their sole locomotive organs. They generally swim with the convex part forwards, and with the greatest rapidity. Sometimes they simply rotate upon their axis, or they tumble over and over; or selecting a fixed point they whirl round it in rapid circles, carrying every loose particle after them. Others creep along the bottom of the watch-glass upon one end and with a waddling gait; but generally after a few hours all motion ceases, and they are found to have attached themselves to the surface of the glass. At the expiration of forty-eight hours the rudiments of a cell were observed extending beyond the margin of the body (fig. 24.); but at this stage the animals invariably perished, and during repeated observations I had no opportunity of witnessing their further metamorphosis. At this stage the cilia had disappeared, and the muscular lobes were no longer apparent. None of these gemmules were spontaneously evolved, and their death appeared to be owing to their premature extraction. The parenchyma of the gemmules has a *contractile* power, somewhat like that of Hydra, but less in degree, by which the form of the body is occasionally altered. If a portion of the margin with the cilia attached be torn off, the cilia continue to vibrate, as when a portion of one of the tentacles has been so isolated.

PLATE XXVII. fig. 1—5.

Membranipora pilosa, Blainv.

Syn. *Eschara Millepora*, Ellis, Corall. pl. xxxi. f. a. A.
Flustra pilosa, Linn., Gmel., p. 3827. No. 3. Blainv., Dict. des Scien. Nat., Art. Zooph., p. 415. Flem., Brit. Anim., p. 537. Gen. lvi. 147.
Flustra dentata, Linn., Gmel., p. 3828. No. 11. Ellis, Corall. pl. xxix. d. Blainv., Dict. des Sc. Nat., p. 414.

This evidently belongs to the genus *Membranipora* of Blainville*, though not included in it by him. It unites *Flustra pilosa* and *dentata*; the only difference between which is in the length of the anterior spine of the cell, a character which varies in every degree even in the same specimen.

Fig. 1. The *animal* in many respects very closely resembles *Halodactylus diaphanus*, but its form is far less elegant. The arms are twelve (rarely eleven) in number, ciliated and furnished with long spines. They are very long in proportion to the body, but thick and rather clumsy, and during expansion are frequently curled inwards at their extremities.

The base of the tentacles appears to be surrounded by a delicate band, which is placed on their outer side as if for the purpose of bringing them together, and immediately within which they unite to form the tentacular ring (fig. 2.). The appearance of a circumferential vessel in the substance of the ring, and the tentacular canals were observed here as in *Halodactylus*.

The pharynx also in every respect confirmed the observations upon that species, especially in its mode of expansion, and in the position of the dark line, the triangular space, &c. The flask-shaped body was here also occasionally observed, but without affording any additional information. It was much larger in proportion to the length

* Dict. des Sc. Nat. Art. Zooph., p. 411.

of the arms, and was sometimes seen to be much distended and to alter its form occasionally (fig. 3 and 4.).

The cardia is placed about midway between the mouth and the base of the stomach, the whole canal being very short. The intestine terminates in the membranous parietes at a little distance below the ring (fig. 1. *a*.). The separation of the parietes from the cell when the animal emerges is very distinct.

The lateral aperture in the cell is filled by the flexible membranous portion, which does not terminate here by setæ, but has a plain margin (fig. 1. *b*.), forming a close ring round the protruding animal. The cells are met with either isolated or aggregated; in the latter case the growth of the young cells is seen in advance of the older ones, and they appear to spring from the upper and back part of the cells immediately below them (fig. 1. *c*.). The cells are often seen connected by cylindrical stems which do not appear to belong to them.

PLATE XXVII. fig. 6—9.

Notamia loriculata, Flem., Brit. Anim., p. 541. Gen. lx. 158.

Syn. *Corallina cellifera mollis ramosissima*, Ellis, Corall., p. 55. pl. xxi. n. 7. b. B.
Sertularia loriculata, Linn., Gmel., p. 3858. No. 31.
Cellularia loriculata, Pall., Zooph., p. 64. No. 22.
Crisia loriculata, Lamx., Polyp. flex., p. 140. No. 250.
Gemicellaria loriculata, Blainv., Dict. des Sc. Nat., Art. Zooph., p. 425.
Loricaria Europæa, Lamx., Expos. méthodique des genres de l'ordre des Polypiers, p. 7.

Fig. 6 and 7. This is a ramified species very common on the Sheppy coast. The arms are ten in number, ciliated and flexible (fig. 9.). The alimentary canal presents the usual details (fig. 8. *a*.) The pylorus is very distinct, and there is a considerable rectal enlargement. The pharynx is spotted. The gizzard wanting.

Fig. 7. The branches, which are given off generally form opposite points of the main stem, are formed like it of a succession of cells, placed back to back in pairs, the last two or three pairs gradually diminishing in size, with a corresponding degree of development of the contained animals; the terminal pair is generally very small, and apparently homogeneous in texture, and without a trace of its future animal inhabitant (fig. 8. *c*.).

Fig. 8 and 9. From this position of the cells the animals cannot emerge from their extremities, but protrude laterally by the oval aperture in the upper part and side of the cell. This is closed, as in *Membranipora*, by a more flexible portion than that which forms the rest of the cell, (which is only a modified form of the flexible operculum in the foregoing species,) leaving a horse-shoe aperture for the passage of the tentacula and upper part of the body (fig. 9. *a*.). Here the process of gemmation occurs in very regular order, the smaller cells as in *Membranipora*, growing from the upper and inner sides of the larger ones immediately below them.

It is evident that in the construction of the cell, *Membranipora* and *Notamia* are closely allied, and notwithstanding the encrusting character of the former species, and the ramified habit of the latter, it would be easy in imagination to convert the one into the other by supposing two lines of growing cells, such as are often seen in *M. pilosa*, to be attached back to back to each other: from these similar branches arising the encrusting species would be converted into the ramifying one. And the further passage of this to the arrangement in *Flustra* is accomplished simply by the union of a parallel series of such branches.

Such then are the principal facts that have offered themselves to my notice during the investigation of the above described species. They afford evidence of the existence of a very decided type of structure, and one which presents a remarkable uniformity of character, notwithstanding that it was observed in genera differing considerably in less important particulars. To what extent, however, this prevails, and how far it may be modified in other genera, are considerations which must be reserved for a more extended inquiry to determine. Among the points requiring further elucidation, one of the most important is the condition of the nervous system. No trace of either nerves or ganglia could be detected; yet the attributes of a nervous system were so clearly exhibited as to leave no doubt but that this must exist, and probably in some degree of perfection. Not only was the delicacy of their sense of touch very strongly marked, but the operations also consequent upon the enjoyment of such a sense were sometimes singularly striking. This is seen in the instant retiring of the animal on the slightest alarm, and the caution which it sometimes shows before emerging again from its cell*; in the obvious selection of its food; and in the pertinacity with which it refuses to expose itself to water that has become in the least degree deteriorated.

The respiratory system, again, being so intimately connected with the digestive apparatus, it becomes difficult to determine, from witnessing the *combined* operations of the parts, in what degree they contribute to the performance of each function *respectively*. The peculiar action by which the pharynx becomes so frequently distended, and the constancy of the currents produced by the tentacular cilia, (apparently far beyond what would be necessary to afford a *sufficient* supply of food,)

* On several occasions I observed in *Halodactylus* one or more of the tentacles protruded and turned over the side of the cell before the animal ventured out again, after having been alarmed by the sudden contact of some vibriones that abounded in the water used, as if to ascertain the presence or absence of the intruder (plate xxvi. f. 7. b.); a position of the arms which is also frequently assumed in this species in the act of retiring. So delicate indeed is the sense of touch, that the creeping of a very small animalcule over the top of one of the closed cells was followed instantly by a shrinking of the soft parts beneath.

together with the circumstance that the particles so brought within its reach seem frequently rather a source of annoyance than of advantage to the animal, are points which would encourage the belief that these parts have a considerable share in the process of respiration; but until the existence of a circulatory system and its course shall have been determined, the consideration of this as a respiratory apparatus must yet remain conjectural, though supported by very strong analogies. On the other hand, its use in ensuring a supply of food to the animal cannot be questioned.

The structure and growth of the cells, and their connecting medium, offer many interesting points for consideration. In the ramified and creeping species the cells are connected by a cylindrical stem, which appears nearly homogeneous throughout, and does not present that obvious distinction between hard and soft parts that is observed in the stems of *Sertularia*. If, however, this stem be cut across, especially when decomposition has commenced, a granular matter flows out, leaving the delicate corneous sheath nearly empty. This corneous case of the stem is easily seen to be continuous with the cells that arise from it, but the internal substance cannot be distinctly traced to the animals as in *Sertularia*. It is probable, however, that it passes gradually into the parietes of the body by which the cells are lined. With the facts before us of the progressive growth of the stem, and the production from it of buds or gemmæ, which gradually develop into mature animals, no doubt can be entertained either as to the vitality of this part, or of the direct communication between it and the *young* animals, at least up to the period at which they begin to emerge from their cells and to seek nourishment for themselves. Nor is it reasonable to suppose that this communication ever after ceases, for then it would be impossible to account for the nutrition of the growing parts, and the combined operations by which the regularity of growth of the whole is maintained, as exemplified in the ramified species by the proportionate thickening of the stem to the number of branches which it has to bear, and in the definite forms which each species assumes.

But it might be questioned whether the whole of the stock is a living part, or only the soft interior; while the more dense exterior, together with the cell, might be regarded as a mere exudation from it. From the various phænomena, however, that occur during the growth of these parts, and from the manner in which they are blended in their early state, I am disposed to consider both the one and the other as organized and influenced by one common vitality.

The *two* processes of reproduction here observed offer many points of contrast. That by *gemmæ*, or buds from the common stock, appears to be uninfluenced by season; the young animals, from the earliest period in which form can be traced in them, resemble in some measure the parent; and their subsequent growth is but a development of that form, and at no period are they separated from the parts that produce them. The process by locomotive ciliated *gemmules* is limited to certain seasons, generally spring; these bear no resemblance to the parent; they appear to be the more immediate produce of the individuals, than of the community; and they separate from the parent at an early period, and must undergo metamorphosis before arriving at maturity. This process of reproduction is entitled to be called *gemmuliparous* as contradistinguished from the *gemmiparous* mode.

The gemmiparous mode is precisely similar to that which takes place in the free Hydra. The resemblance is nearest when there is no connecting stem, as in *Membranipora*, *Cellaria*, &c. Here the gemmæ sprout apparently only from the cells, but doubtless also in connection with the parts of the body by which they are lined. When a stem is present the gemmæ do not arise from the cells, but always from this, which is but an extension of the reproductive surface. In either case the buds are at first homogeneous throughout, and their separation into cell, parietes, and alimentary canal, is a subsequent process of growth.

With regard to the mode by ciliated gemmules, it would be important to ascertain the origin and exact condition of these previous to their separation; and also to determine whether they have any relation with the brown bodies so frequently observed in the visceral cavity. These latter I found sometimes, after being kept several days, converted into mere cysts full of living animalcules, which however bore no resemblance to the mature gemmules.

Quitting, then, at this stage of the inquiry the further consideration of this type of structure, it will follow next in order to show what position it will hold with reference to other portions of the animal kingdom; and for this purpose it will be necessary to consider the relative value of its different characters.

In the absence of a knowledge of the condition of the nervous system, the characters, at once the most obvious and important, are derived from the apparatus for entrapping and digesting the prey; and the structure of the tentacula, and the form of the alimentary canal, will of themselves be sufficient to constitute the distinguishing features of this type, connected too as the former appear to be with the very important process of respiration. Indeed the combination of ciliated tentacula with a free alimentary canal, having two external openings, appears so uniform, that the presence of the one being determined, the structure of the other, and indeed more or less of the entire animal, may be fairly inferred.

With this view of the subject I propose for this class the name *Ciliobrachiata*, a name which, by seizing one of the most prominent features, will serve at once to distinguish those animals, to which it is applicable from all inferior types.

The Ciliobrachiata, therefore, will comprehend the fourth family of Polypes of Milne Edwards, the Bryozoa of Ehrenberg, and the Polyzoa of Thompson; and in applying a new name to a group of animals previously, but imperfectly, indicated by others, I do so with a wish to stamp upon it those distinguishing features which it has been my object in the present essay to point out, and in preference to adopting others which, as expressive of characters common to it with inferior types, might only tend to carry on the errors that have given rise to so much confusion with regard to the subject.

With a view to a subdivision of this class, after a more natural method than has hitherto been followed in arranging the various forms of Polypes, it would be desirable to regard the varieties presented by the alimentary canal, which from the conspicuous position of the parts are the more easily determined. Thus the presence or absence of the manducatory organ are points of much importance; and the position of the anus may be also worthy of consideration. The structure of the *alimentary canal*, however, will probably be found to present but few essential points of difference, and it may be necessary soon to revert to the form of the *cell* as a secondary means of distinction. The position of the aperture and the character of the operculum then becomes of consequence, especially in its mode of termination, whether by separate spines or by a notched or smooth margin. But if it be found that where the aperture of the cell is *lateral* the manducatory organ is sometimes present, and in other cases absent, as I have shown it to be when the aperture is *terminal*, then the character of the cell must yield in importance to that of the alimentary canal, and the animals be arranged accordingly. With the lateral position of the aperture the operculum is generally simple, and the cells have seldom a distinct connecting medium. But where the aperture is terminal the operculum is more complicated, and the cells are generally united by a ramified or creeping stem; but the passage from the one form of arrangement to the other is shown in *Halodactylus*, in which the cells, though usually placed perpendicularly with their sides in contact, and the aperture terminal, are yet sometimes placed so obliquely as to resemble in arrangement an encrusting species, having the aperture directed laterally. The structure of the cell, however, is not in this case affected by its accidental position.

It will then be of consequence to determine the degree of importance to be attached to those characters which have been erroneously considered primary, namely, those that are derived from the common mass, or polypary. These, however, are generally the most superficial and least important; since a very slight alteration in the arrangement of similar parts will give a very different character to the whole, as exemplified in the readiness with which an encrusting species might be converted into a ramified, and that again into a foliaceous one. But the mode of growth of the stem might occasionally afford useful characters for generic distinctions; thus the definite mode of growth in *Vesicularia spinosa* is contrasted with the irregular arrangement of the cells in *Bowerbankia* and *Lagenella*; whilst trivial characters are readily found in the number of the arms, and similar points of inferior importance.

In natural affinities *Ciliobrachiata* is evidently allied both to *Tunicata* and *Rotifera*. In *Tunicata* the tentacles are reduced to mere rudiments at the entrance to the respiratory sac, and the cilia are distributed over the surface of this cavity, which is in proportion magnified, and is analogous to the pharynx of *Ciliobrachiata*. The more immediate entrance to the alimentary canal, thence called mouth, being situated at the bottom of this sac, corresponds with the part that I have called *cardia*; and the analogies between the remaining course of the alimentary canal, position of the ovary, nature of the external covering, and other points of resemblance between the two classes, are easily traced.

But between *Ciliobrachiata* and *Rotifera* the affinities are still nearer. Taking *Hydatina* as the representative of the latter class, the cilia (which, however, differ in form) are placed on short lobes instead of arms. The pharynx is very short, and leads at once to the manducatory organ, which guards the entrance to the stomach, as in *Bowerbankia*. The muscular apparatus for altering the form of the body is identical in the two classes, and in the general character of the body and position of the contained parts there is a very close resemblance. They vary, however, in their mode of reproduction, position of the anus, and other points.

The Ciliobrachiate polypes being thus separated from the rest of their associates by characters well defined and easily recognized, there yet remain two other types, which may be represented by *Hydra* and *Actinia*, the *Hydriform* and the *Actiniform*, or *Zoanthiform* polypes.

Of these two, the Hydriform polypes, whilst they are the furthest removed from *Ciliobrachiata* in degree of organization, are nevertheless those which have been most frequently confounded with them. For it would appear that in the lower type the superficial characters of the higher are sketched, as it were, in outline; so that whilst they are found to differ materially in intimate structure, there yet remains a sufficient resemblance in external configuration to have caused them to be confounded together. The Hydriform polypes may be recognized by the granular structure of the body, by the entire absence of a stomach distinct from the parietes, by the single external opening to the cavity, and the absence of cilia from the tentacula.

The granular parenchyma of the body having a contractile power in every part, the alterations in its form and dimensions are effected without the necessity for a distinct muscular apparatus. No folding of the body takes place when the animals withdraw into their cells, where they are still left more or less exposed from the absence of a distinct operculum. The food is received at once into the main cavity of the body which constitutes the stomach, there to be acted upon by the granular parietes; and whilst the egesta escape by the same orifice by which they were taken in, as in *Hydra*, the nutrient particles have been traced to the tentacula in the free animals; and in the compound ones as flowing in a stream through the tubular fleshy medium which communicates with the stomach, and by which all the animals are united.

As in the higher type the tentacular cilia appear to be concerned both in nutrition and respiration, so their absence in the present case must be viewed with reference to both these points. With regard to the greater choice of food afforded by the action of cilia so placed, this appears to be less necessary where the body is of such a structure as to be capable of accommodating itself to prey of a greater variety of size; whilst, for purposes of respiration, the exposure of the entire surface of the body to the water, which has free access to the cell, may be sufficient, without the necessity for that constant renewal of it that a more complicated organization appears to require.

The absence of the ciliary character of the arms, in the present case, appears to be as uniform as its presence in the former; and as so much of the economy of the animal turns upon this single point, one more characteristic could not perhaps be selected. I propose, therefore, to unite all those animals, which, partaking of the nature of *Hydra*, present this character, into a second class, to which the name *Nudibrachiata* might be applied.

This class will comprehend the second family of polypes of Edwards, and the *Dimorphææ* of Ehrenberg. The more interesting forms of it have been so well illustrated by the very interesting descriptions and figures of Mr. Lister, in the paper already referred to, that I have no occasion to add any here.

The points in which *Nudibrachiata* approach nearest to *Ciliobrachiata* are (with the exception of the mere contour of the body), the general habit and mode of growth, and the process of reproduction. The former character I have shown to be extremely superficial, and one that should be considered as among the least important in a natural arrangement. It presents but little essential difference in the two classes. In the structure, however, of the more solid parts there appears to be a deficiency of the earthy material in the lower class, which in the higher is blended in greater or less quantity with the horny matter. The gemmiparous and gemmuliparous mode of reproduction appears to be similar in the two classes.

The *Nudibrachiata* will probably continue to hold that position in the animal kingdom which has been usually assigned to the entire class *Polypi*.

The class *Polypi* being thus deprived of two of its principal divisions, which, whilst they resemble each other so much in superficial character, as to require the aid of the microscope to distinguish them, in their intimate structure hold the two extreme positions; the third division only remains. But this is by far the most extensive, and the animals are seldom or never so small but that their characters may be readily discerned by the unassisted eye, while many attain a considerable size.

This division corresponds with the third family of Polypes of Edwards, and forms the *Anthozoa* of Ehrenberg, (deprived of the *Hydræ* and *Sertulariæ*,) as last constituted by him. In this state I shall leave it, merely adding a few remarks on its natural affinities which necessarily arise out of the consideration of the two former classes, and in order to complete the view of the subject.

The *Anthozoa* will comprehend the corticiferous polypes, together with the free and associated *Actiniæ*, and indeed all those forms to which the familiar term "Animal Flower" has been most frequently applied.

The body is here distinctly membranous, and the stomach forms a separate pouch suspended in its centre. The stomach has but *one* external orifice, which serves for mouth and anus; but posteriorly it communicates with the main cavity of the body. This, in *Actinia*, is divided perpendicularly by septa, passing from the stomach to the sides of the body; and with the chambers thus formed the short tubular arms that are set round the mouth communicate. In these tubular processes a constant circulation of fluids may be observed passing up from the chamber of the body and returning to it again. They appear to answer the double purpose of prehensile tentacula and of respiratory tubes. They are not ciliated externally*, and in form have little resemblance to the tentacles of the other two classes. In this respect, however, they vary very much, being, in some forms of *Actinia*, arranged simply in one or more circles round the mouth; in others, elevated upon semilunar lobes; whilst, in other instances, as in *Xenia*, *Gergonia*, &c., these lobes may be supposed to be drawn out into the conical or cylindrical arms, having a dentated margin; in which cases the whole arm does not correspond with a single arm of *Actinia*, but each of the dentiform processes upon its sides. The character of distinct ovaria producing ciliated gemmules appears to be very prevalent through this class.

The *Anthozoa*, then, are distinguished from *Nudibrachiata* chiefly by the separation of the stomach from the parietes of the body, which has a membranous character; and from *Ciliobrachiata* by the single external opening, and the absence of cilia from the surface of the arms. They appear to hold a place immediately below *Acalepha* and *Echinodermata*, the transition between these three classes being exceedingly gradual.

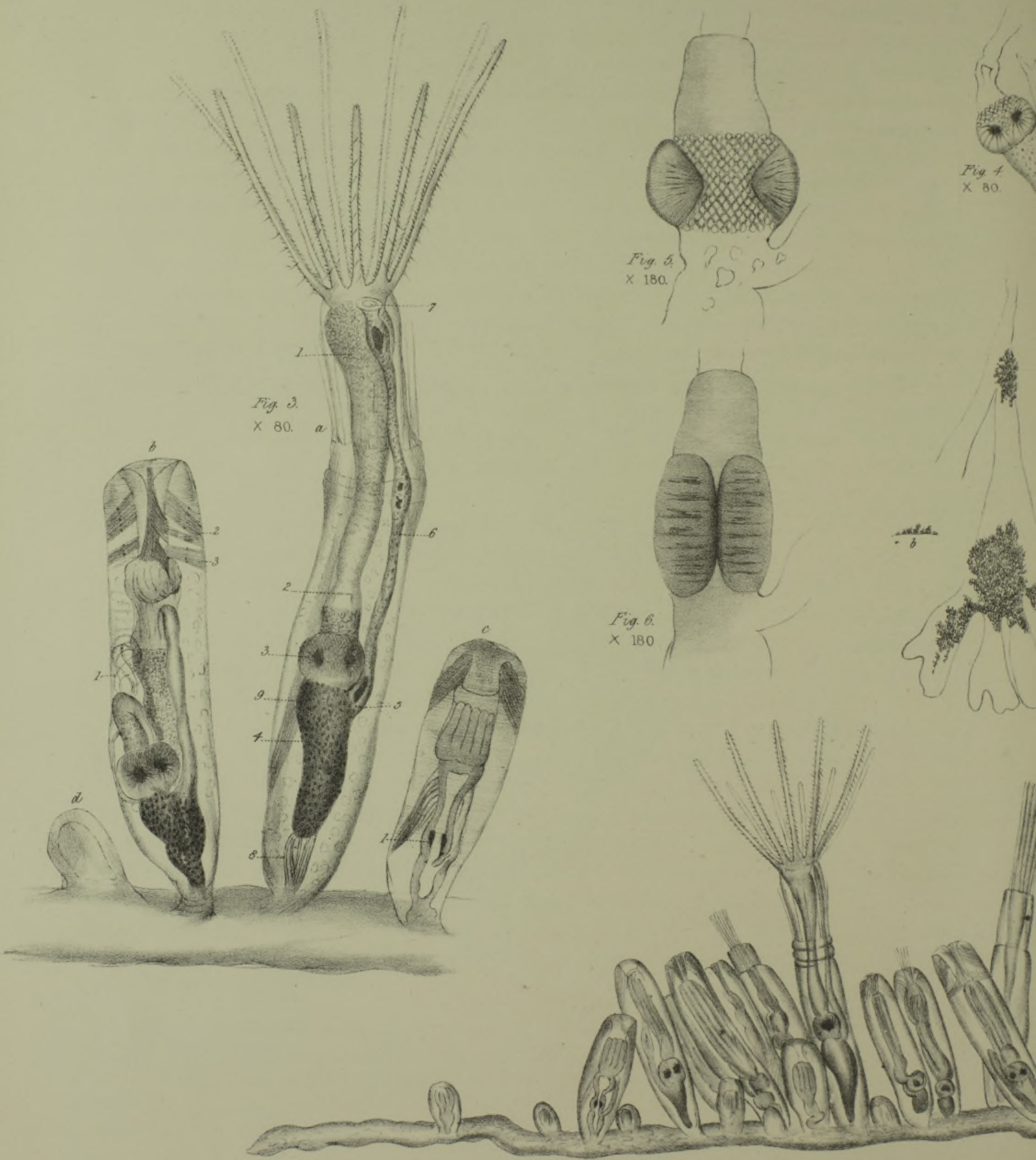
Thus, with *Asterias*, the affinities are easily traced. The single external opening to the membranous stomach is found equally in *Actinia* and *Asterias*; but while in the former this organ communicates posteriorly with the main cavity of the body, in the latter it is closed in this position, and the immediate communication cut off. Again, in the conical arms of the corticiferous polypes, with their fringe of tubular processes, may be traced the analogue of the rays and respiratory tubes of *Asterias*; both are distended by the fluids which circulate through them, probably for respiratory purposes. Moreover, in the position and form of the ovary the closest resemblance exists; and when to these points is added the stem of the crinoid animals, the affinities between the two classes are rendered still more striking.

Again, between *Anthozoa* and *Acalepha* analogous points of resemblance might be traced; and here again the transition appears so gradual that it might be difficult to determine where the one ends and the other begins.

Thus, then, it appears that under the commonly received name of *Polypi* there exist *three* distinct types of structure, which must be referred to the same number of separate classes, possessing but few points in common, and those generally of the most superficial kind, but which have nevertheless induced naturalists, from the want of a sufficient degree of attention to their intimate structure, to group together, in accordance with such superficial resemblance, animals that have no title to be classically associated.

* It might be objected that as the arms of *Anthozoa* are not ciliated, at least externally, the term "*Nudibrachiata*" is equally applicable to this class. The *Anthozoa*, however, could never be confounded with either of the other two classes, to the *mutual* distinction of which the names that I have applied to them have reference.

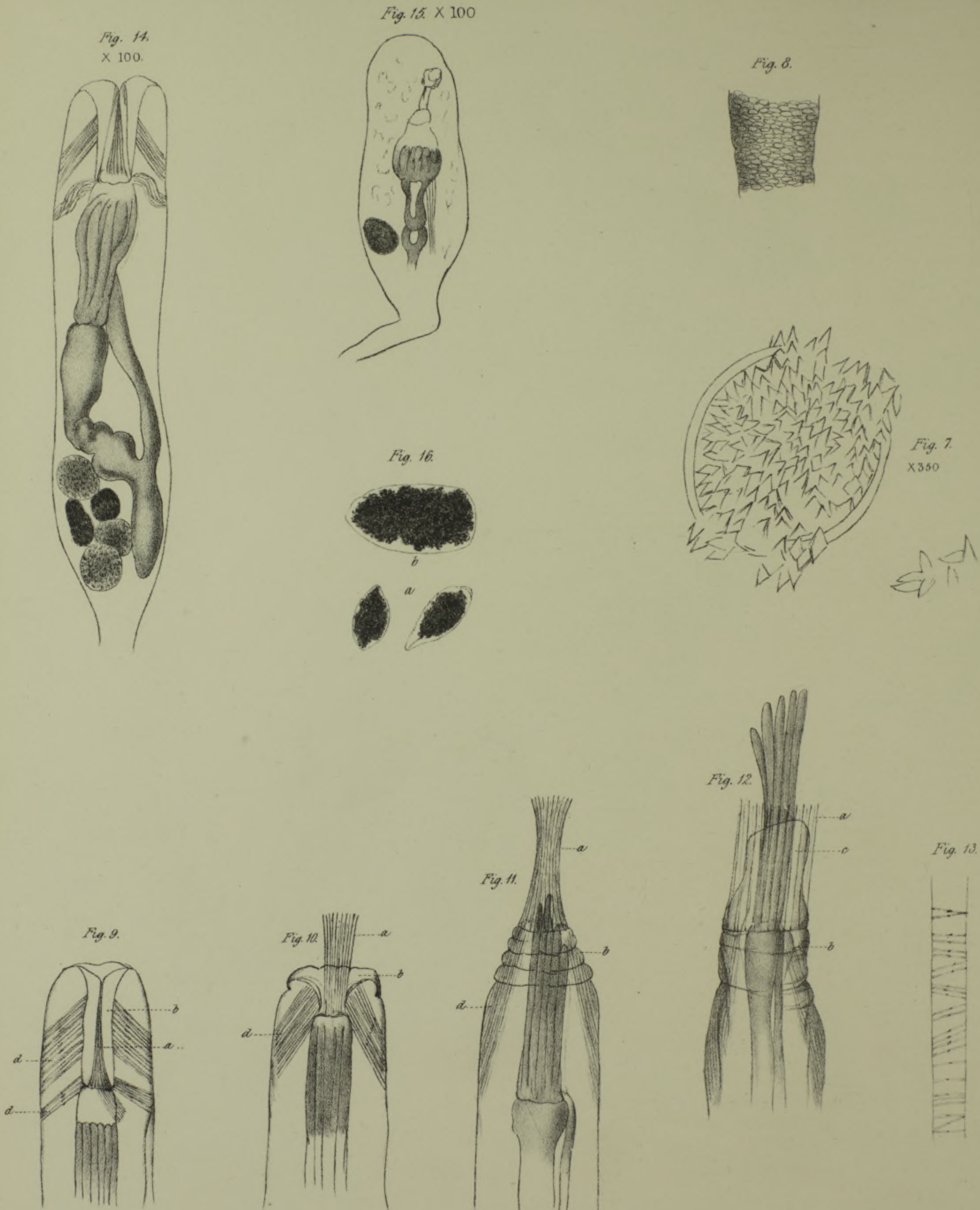
Ciliobrachiata



Parasitic on Flustra foliacea

Bowerbankia densa

Arthur Farre. del.



Bowerbankia densa.

Arthur Farre, del.

J. Basire lith.

Vesicularia spinosa, Thomp.

Ciliobrachiata.

Fig. 1.

Fig. 2. × 6.

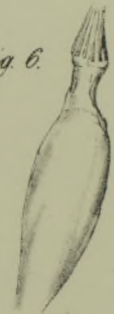


Fig. 6.

Fig. 5. × 250.

Fig. 4. × 100

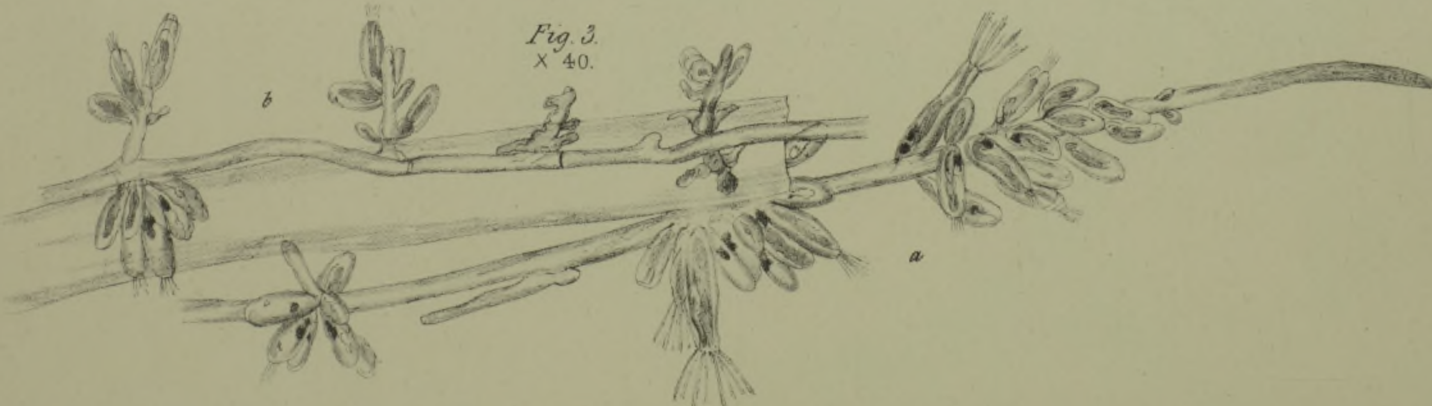


Fig. 3. × 40.

Valkeria cuscuta. Flem.

Ciliobrachiata

Lagenella repens.

Arthur Farre, del.

Ciliobrachiata.

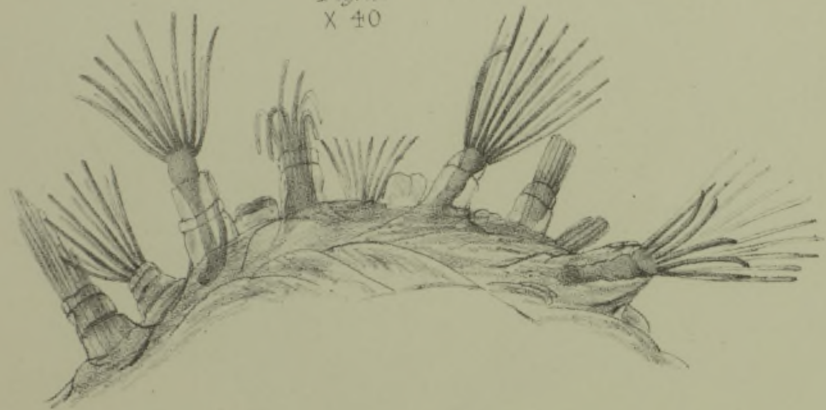


Fig. 2. X 40

Fig. 1.

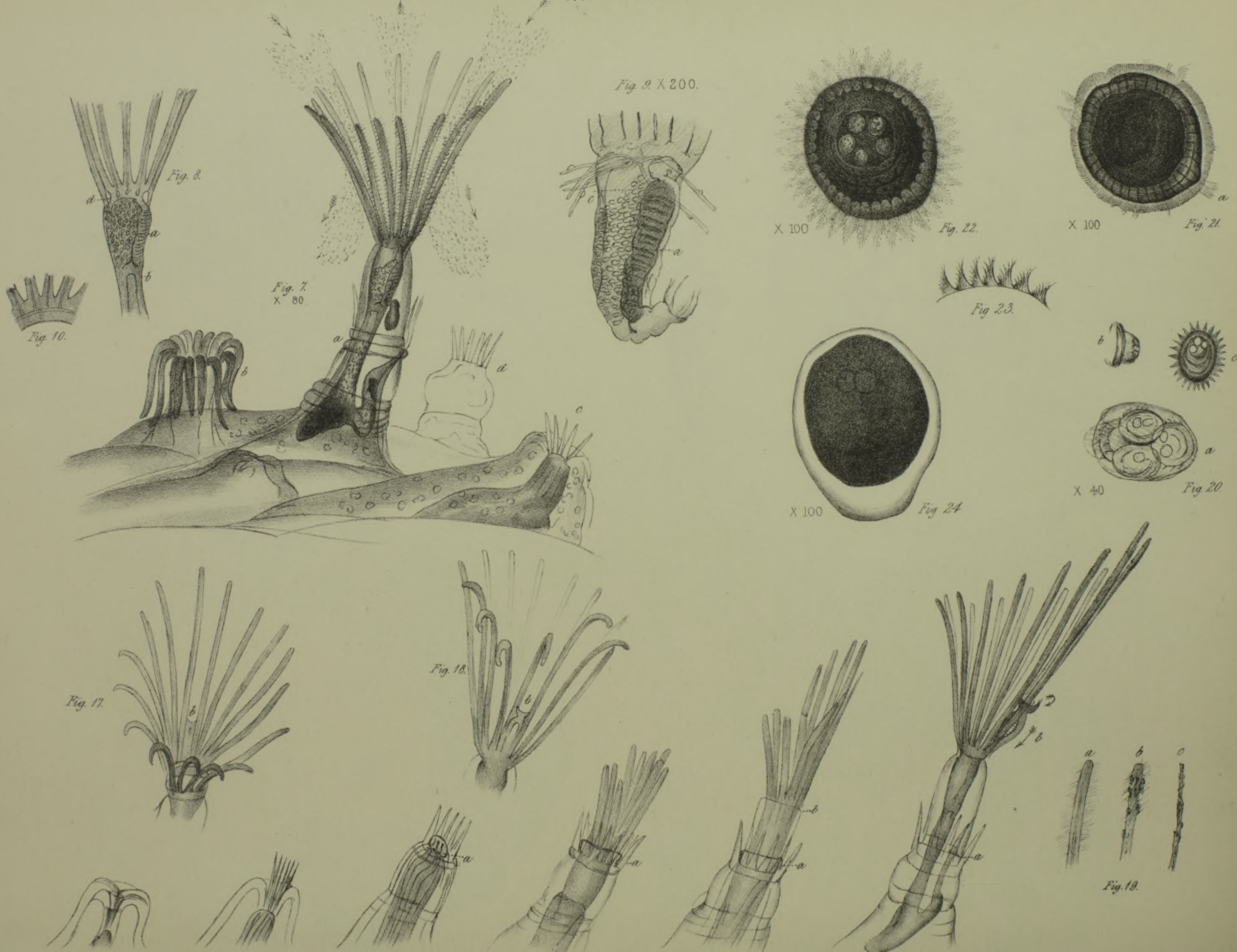
Fig. 4. X 80

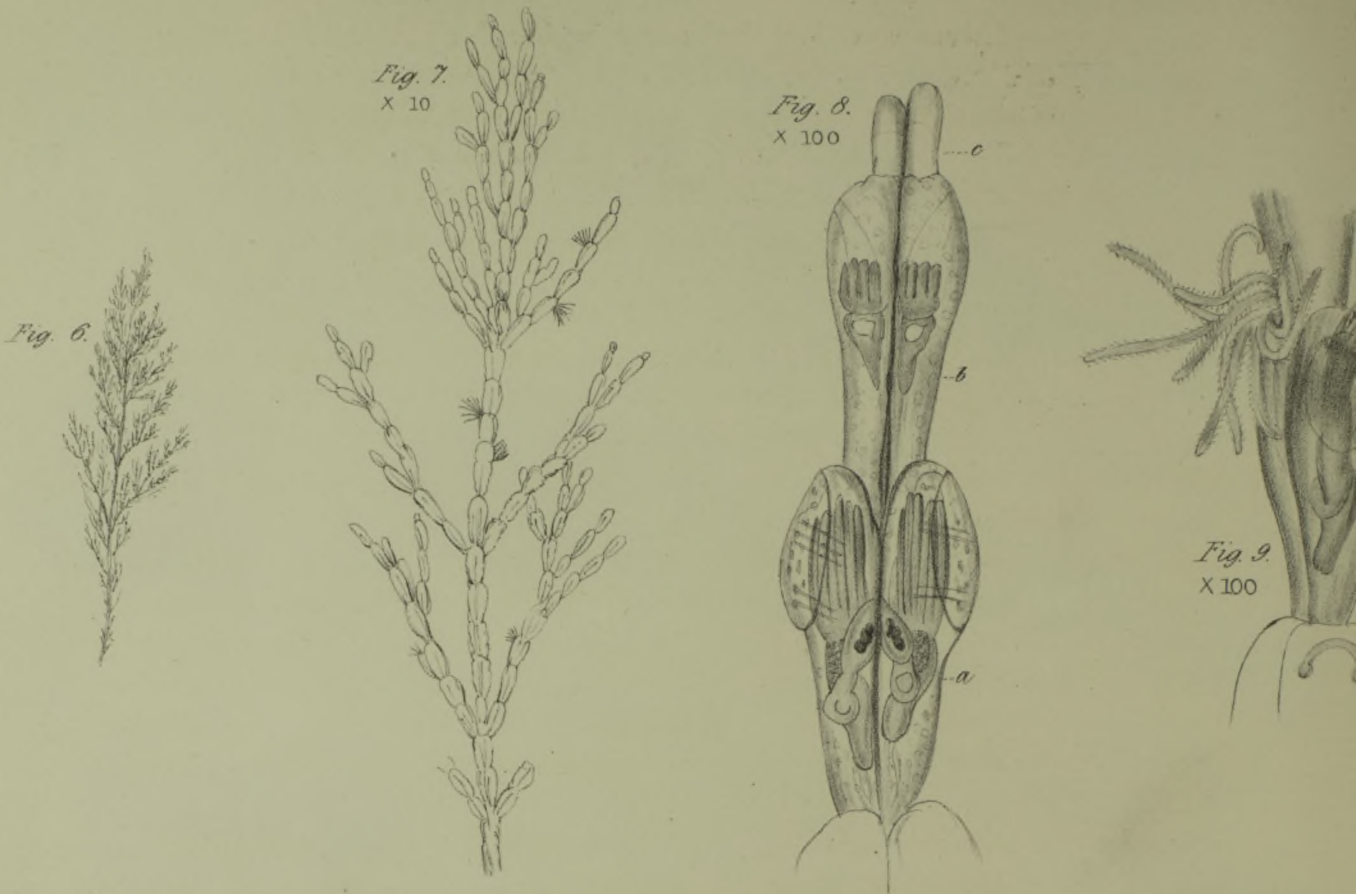
Fig. 3. X 40

Fig. 6. X 100

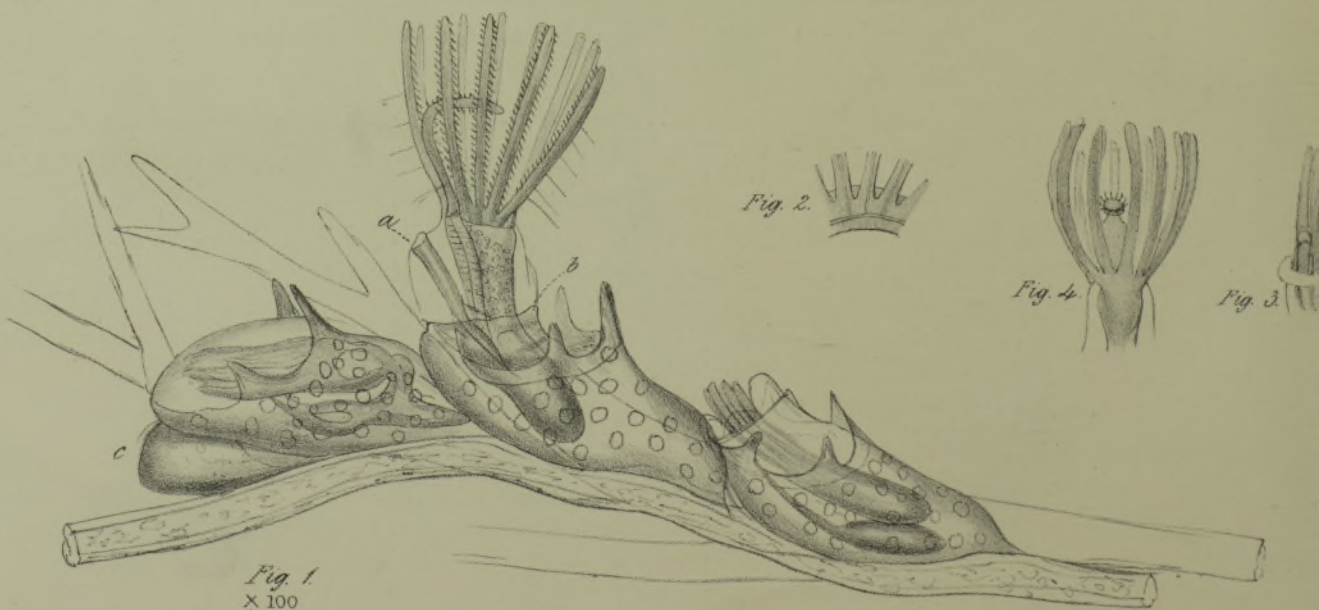
Fig. 5. X 80

Ciliobrachiata.





Notamia loriculata. Flem.



Arthur Farre, del.

Membranipora pilosa. Blainv.

Description of the Plates*.

The linear enlargement of each figure is expressed by the numbers with the sign × prefixed.

Ciliobrachiata.

Plate XX. and XXI. fig. 1 to 16. p. 391.

Bowerbankia densa.

Fig. 1. *a.* A specimen of the natural size, with the creeping stems closely set upon a piece of *Flustra foliacea.*

b. A portion of the same separated.

Fig. 2. × 40. The same as fig. 1. *b.* The animals are seen in various positions, and in all stages of growth.

Fig. 3. × 80. *a.* One of the animals fully expanded. 1. Pharynx. 2. Cardia. 3. Manducatory organ, or gizzard. 4. Stomach, its parietes studded with the hepatic follicles. 5. Pylorus. 6. Intestine, containing pellets of feculent matter. 7. Anus. The gastric (8) and tentacular (9) retractors are seen within the cavity of the body. The flexible portion of the cell, or the operculum, is seen expanded and surrounding the upper part of the body.

b. A similar animal completely retracted. The stomach drawn to the bottom of the cell. The upper portion of the alimentary canal flexed. The tentacula somewhat distorted by the pressure of the operculum. Their retractor filaments relaxed, 1. The upper part of the cell is occupied by the operculum folded up in its axis, and from it the upper and lower sets of opercular retractors are seen radiating, and in their contracted state. 2 and 3. These filaments are about $\frac{1}{6,500}$ inch diameter in this state.

c. An immature animal. The tentacula and alimentary canal rudely formed; the cavity in the latter very distinct. The tentacular and opercular retractors also shown. 1. The gizzard.

d. One of the gemmæ in its earliest state. The cavity just defined, but no animal distinguishable.

Fig. 4. × 80. Portion of the alimentary canal, showing very distinctly the cardia. Gizzard with the dark points, radiating lines and teeth. Hepatic follicles and pylorus.

* In the representation of specimens of the *natural size,* I have in most cases selected such small portions as may be just sufficient to afford a recognition of the species, to avoid encumbering the plates with points which are of minor importance, and which, moreover, would be unsuited to pages not devoted to zoological subjects. This remark is particularly applicable to the figure of *Halodactylus,* Pl. XXV. 1., which conveys no idea of the size to which the aggregate masses sometimes attain.

Fig. 5. × 180. The gizzard relaxed, with the dark bodies or constrictor muscles seen on opposite sides, and projecting into its cavity. The inner surface lined with teeth.

Fig. 6. × 180. The same in a state of contraction. The dark bodies elongated and brought into apposition, obliterating the cavity. (Both these figures as seen when the interior of the organ is in focus.)

Fig. 7. The gizzard torn open, and the teeth displayed.

Fig. 8. Portion of the pharynx, with the markings upon its surface.

Fig. 9 to 11. A series to show the mode in which the operculum and upper part of the body is unfolded. The same animal is represented in four different stages.

Fig. 9. *First stage.* The top of the cell completely closed. The setæ, folded up in the centre, 9 *a*, with the flexible portion of the cell *b* inverted and closely surrounding them. The muscles contracted, *d d*.

Fig. 10. *Second stage.* The bundle of setæ *a* rising from the centre of the cell, being forced upward by the pressure of the tentacula. The flexible portion *b* rolling from around the setæ, and the muscles *d* put upon the stretch.

Fig. 11. *Third stage.* The flexible portion *b* completely everted. The setæ *a* still lying together. The tentacles just appearing between them.

Fig. 12. *Fourth stage.* The tentacula appearing above the margin of the operculum. The *integument of the body*, which forms the tentacular sheath half everted, *c*. The operculum completely expanded. The letters refer to the same parts in all. The *last stage* is seen in fig. 3. *a*. where the eversion of the integument is complete and the tentacula separated. (These stages are taken arbitrarily, the process being continuous.)

Fig. 13. The parietal muscles which assist in the act of protrusion. The knot is seen in the centre of each.

Fig. 14. Showing the position of the brown and white bodies. (Query, ova.)

Fig. 15. The same in a young animal.

Fig. 16. *a*. Two of these separated from the body.

b. More highly magnified, showing the external membranous sac with contained granular matter.

Plate XXII. p. 401.

Vesicularia spinosa.

Fig. 1. × 3. A portion of the stem with the branches springing from its angles.

Fig. 2. × 40. Small portion of a growing branch. The cells strictly unilateral, and

showing a regular gradation in growth. The apertures are seen left by the falling off of the cells, and below them the apparent line of connexion. The stem occupied by granules.

Fig. 3. × 100. The animal expanded (not very perfectly). The arms and alimentary canal short compared with the former species. The gizzard and other parts the same. The parietes seen separated from the cell at *a*.

Fig. 4. A similar animal in the act of protruding.

Fig. 5. Another completely retracted. The parietal granules seen in each of these figures.

Fig. 6. A young animal.

Fig. 7. Upper half of a cell, showing the setæ.

Fig. 8. Two animals, showing the various muscles.

a. Gastric retractors.

b. *b*. Tentacular retractors.

c. *c*. *c*. Parietal muscle.

d. *d*. *d*. *d*. Opercular retractors.

Plate XXIII. p. 402.

Valkeria cuscuta.

Fig. 1. Natural size. Growing on *Ceramium*, like Dodder.

Fig. 2. × 6. A similar portion separated.

Fig. 3. × 40. Two portions showing the arrangement of the cells. At *a* in groups surrounding the stem, and sessile. At *b* raised upon short branches from each joint. On a portion of *Ceramium*.

Fig. 4. × 100. Group of animals.

a. Expanded

b. Retracted.

This figure shows also the opercular retractors, the brown body and the parietal granules. These two latter are also seen in the cell *c*, which in other respects is empty.

Fig. 5. × 250. Single animal magnified to show the cercariæ in the cavity of the body.

g. Separate cercariæ.

a. Tentacula.

b. Line in the pharynx.

c. Stomach.

d. Pylorus.

e. Rectal enlargement of intestine.

f. Operculum protruding.

Parietal granules and muscles distinct. The *gizzard wanting* in this and all the following species.

Fig. 6. Empty cell showing the operculum terminating in setæ.

Plate XXIV. p. 403.

Lagenella repens.

Fig. 1. Natural size, parasitic on *Sertularia*.

Fig. 2. × 40. Portion of the same. The animals in various positions and stages of growth, connected by a creeping stem, and mixed with *Membranipora pilosa*.

a. Side of the cell indented by the pressure of the surrounding fluid when the animal protruded.

Fig. 3. × 100. *a*. Animal protruded. 1. Triangular space in the pharynx. 2. Stomach *during digestion*. The hepatic follicles *large and very distinct*. The food tinged with their secretion. The pylorus well marked. 3. Parietes separated from the sides of the cell by the action of the parietal muscle. 4. Notched margin of operculum.

b. and *c*. Two animals retracted. The operculum drawn towards one side by the single retractor. The stomach suspended by the intestine from the top of the cell; at *b* 2. the stomach is seen *pale and empty*, and the hepatic follicles *barely visible*. *b* 3. Parietal muscles.

This figure (*b*.) exhibits the appearance *invariably* presented by all the animals of this class when they have remained for a day or two without emerging from their cells, and consequently without a fresh supply of food; emptiness of the stomach, being in every case accompanied by a pale and nearly transparent state of its parietes, and a reduction of the follicles to the finest points; while the full stomachs appear as represented at *a*. These characters are so striking when pervading an entire specimen, as at a glance to furnish the observer with a ready test of the purity of the water employed, and of the degree of vigour of the little animals under examination.

d. Figure showing the muscles. 1. Gastric. 2. Tentacular and 4. Opercular retractor. 3. Two sets of parietal muscles.

e. *e*. *e*. Gemmæ in various stages.

Fig. 4. Parietal muscles in a state of relaxation.

Fig. 5. The same in a state of contraction. Their diameter doubled.

PLATE XXV. and XXVI. p. 405.

Halodactylus diaphanus.

Fig. 1. A small specimen of the natural size. The animals seen protruding from its surface.

Fig. 2. × 40. The appearance presented by a *lateral view* of the *surface*. The animals in various stages of protrusion. Their diameter doubled.

Fig. 3. × 40. Thin *transverse* section of fig. 1. The centre occupied by a cellular tissue and water. The circumference formed by the cells in close apposition. The brown bodies scattered through the substance.

a. a. Position of the gemmules, enclosed in the sac.

b. One of the gemmules escaped during the section into the central tissue.

Fig. 4. × 80. Thin slice from the surface, with a *terminal view* of the cells, showing their mode of arrangement, and various stages of growth.

Fig. 5. × 80. A similar slice from a specimen which afforded a *lateral* view of the cells, as in *Flustra*. The muscles and granules distinct in both figures.

Fig. 6. × 80. A young animal extracted, rudely formed. The cavities in the alimentary canal and arms are very distinct.

Fig. 7. × 80. Group of animals. (*Lateral* view of the *surface* as in fig. 2.)

a. Fully expanded. The arrows mark the direction of the particles of carmine, in the currents produced by the ciliated arms.

b. The arms turned over the margin of the cell as if to feel, preparatory to the entire protrusion of the animal.

c. Animal nearly retracted.

d. Empty cell.

Fig. 8. Pharynx, with portion of tentacula.

a. Pharyngeal line.

b. Cardia.

d. Constricted portion of pharynx; above are seen the tubes in the arms and the apertures at their base.

Fig. 9. The pharynx, with squamiform spots, triangular space, *c.* and dark line, *a.*

Fig. 10. Appearance of a circumferential vessel in the tentacular ring.

Fig. 11 to 16. A series illustrating the act of protrusion at different stages; at *a.* figs. 14, 15 and 16 is a circular band within the setæ, apparently for the purpose of bringing them together, seen contracted at *a* 13. *b* 15. Integument half inverted, forming tentacular sheath.

Fig. 16. *b.* Flask-shaped body. Lateral view. The arrow denotes the course of the ciliary motion. This specimen shows the oblique termination of the tentacula.

Fig. 17. *b*. Posterior view of flask-shaped body.

Fig. 18. *b*. Anterior ditto. (The cilia are not represented in these latter figures; they are seen in fig. 7.)

Fig. 19. *a*. Portion of recent arm. The cilia very numerous.

b. *c*. The same when perishing.

Fig. 20. × 40. *a*. Sac containing gemmules.

b. Single gemmule in the act of swimming, with the cilia curved downward.

c. The same viewed from above. The *waves* of cilia appearing as single cilia.

Fig. 21. × 100. A gemmule seen from the under surface. The greater part of the cilia folded up. The muscular lobes shown.

a. The cilia that have a distinct motion from the rest.

Fig. 22. The same from above. The cilia as when slowly acting round the margin in waves. The muscular lobes more distinct.

Fig. 23. The appearance of the cilia when in rapid action.

Fig. 24. The same after forty-eight hours, when it has become fixed and the formation of the cell commenced.

Plate XXVII. fig. 1 to 5. p. 412.

Membranipora pilosa.

Fig. 1. Three animals in different positions. A fourth growing at *e*.

a. Anus.

b. Margin of operculum. These were parasitic on the filaments surrounding the stem of *Vesicularia spinosa*.

Fig. 2. Circumferential and tentacular canals.

Figs. 3 and 4. Flask-shaped body.

Fig. 6 to 9. p. 413.

Notamia loriculata.

Fig. 6. A branch of the natural size.

Fig. 7. × 10. Portion of ditto.

Fig. 8. × 100. *a*. Animal fully formed. Pylorus and rectal enlargement very distinct, the latter distended by feculent matter.

b. Young animals.

c. Buds yet homogeneous in texture.

Fig. 9. Animals in different stages of protrusion.

a. Horse-shoe aperture in membranous operculum.