Annals and Magazine of Natural History: Series 2
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tnah08

XVIII.—On the anatomy of the freshwater Bryozoa, with descriptions of three new species

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Published online: 17 Dec 2009.

cated by the above reactions. They likewise show the presence of chloride of sodium, potash, sulphuric acid and magnesia.

In comparing this secretion of the leaves of the Ice-plant with the fluid in the ascidia of *Nepenthes*, we find a material difference in their respective compositions, as will be seen by the annexed table, which exhibits the composition of both fluids. :—

Composition of the fluid in the ascidia of Nepenthes.	*Composition of the watery secretion of the leaves of* Mesembryanthemum crystallinum.
Organic matter, chiefly malic and a little citric acid.	Organic matter (albumen, oxalic acid, &c.).
Chloride of potassium.	Chloride of sodium.
Soda.	Potash.
Lime.	Magnesia.
Magnesia.	Sulphuric acid.

XVIII.—*On the Anatomy of the Freshwater* Bryozoa, *with descriptions of three new Species.* By Albany Hancock, Esq.*

[With four Plates.]

During a ramble made last July in company with "The Tyneside Naturalists' Field Club" to the Northumberland lakes, I was fortunate enough to find two or three species of *Bryozoa*. Since then I have revisited the locality twice, and on each occasion additional species occurred. Thus six or seven forms of these interesting animals have been found to inhabit two of these lakes, namely Bromley Lough and Crag Lough. Three of the species appear to be undescribed; these I propose to characterize towards the close of this communication, giving previously an account of the anatomy of the freshwater *Bryozoa* so far as I have been able to determine it.

Amongst the known species was a fragment of *Alcyonella*, most probably *A. stagnorum*; but its characters could not be determined on account of the imperfection of the specimen. *Fredericella sultana* occurred abundantly and of very luxuriant growth, spreading over the under surface of stones in patches of three or four inches' extent. Of the new species two belong to *Plumatella* and one to *Paludicella*, a rare genus, of which there was but one species previously known, and that I believe had been found only in Ireland, and in two or three localities on the continent.

The anatomy of the freshwater *Bryozoa* had been very little studied on this side of the Channel before Professor Allman took up the subject, and he has handled it so well that little is left to

* Read at a Meeting of the Tyneside Naturalists' Field Club, Dec. 1849.

be done. Indeed so complete are the results of this naturalist, that, perhaps, the publication of my own may appear almost unnecessary. My investigations, however, carried on as they have been perfectly independent of the researches of others, may not be without some value even where novelty is wanting. Microscopic investigations conducted by the aid of transmitted light are liable to error. Frequent examinations in such cases are therefore necessary, and observations independently prosecuted are of peculiar value. Consequently I do not hesitate to give the result of my own labours on this subject, fraught as it is with difficulty, not fearing to mislead in a path already so well trodden.

Of the anatomy of these animals I shall have to confine myself almost entirely to that of *Plumatella, Fredericella* and *Paludicella*. Of *Alcyonella* I can say but little, having seen only an imperfect specimen, and none of the other freshwater forms have come under my notice.

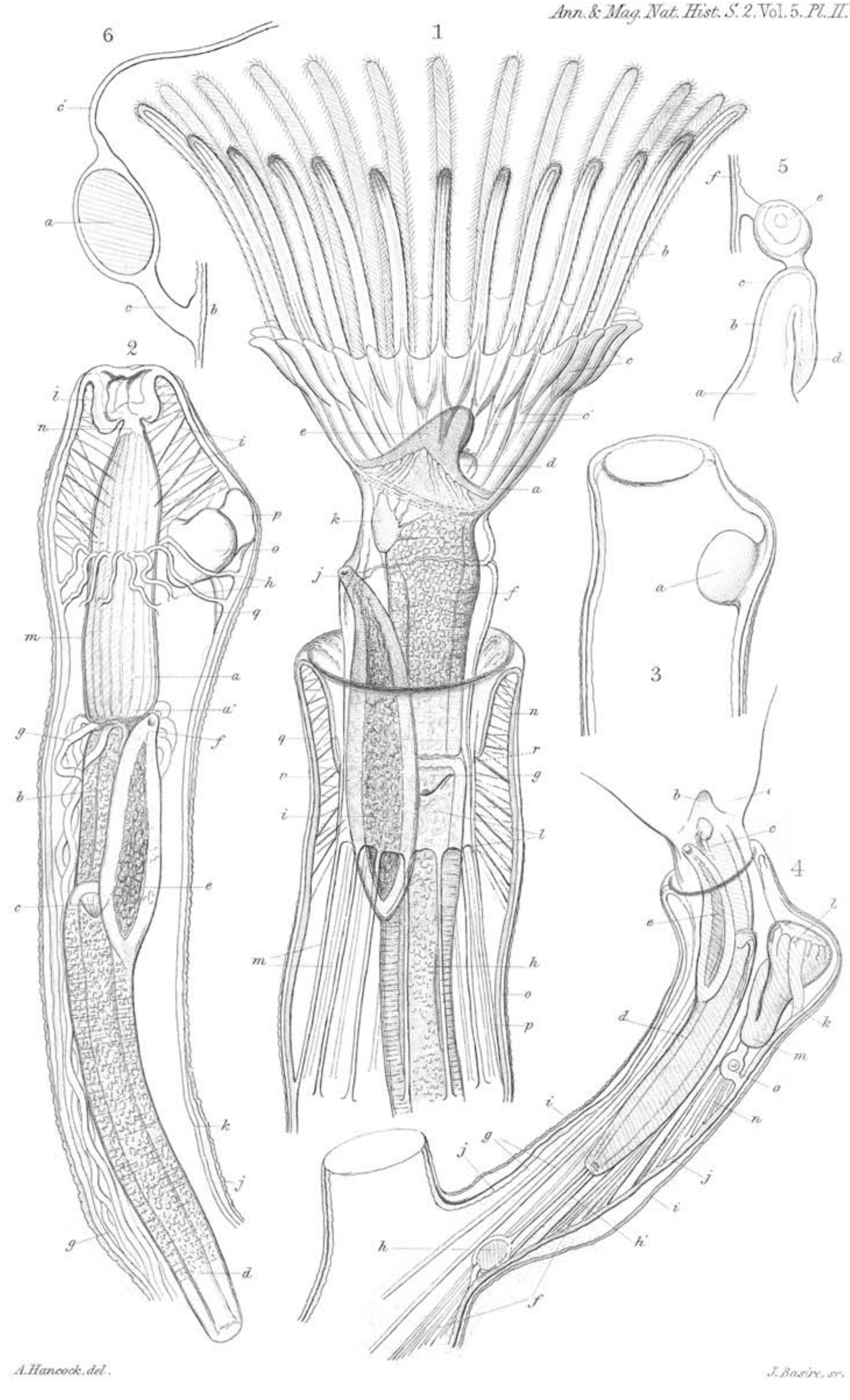
Plumatella and *Fredericella* resemble each other very closely in their anatomical structure, notwithstanding the external difference of their polypes. *Paludicella* however shows some very interesting modifications, particularly in the muscular system: but before entering on the internal anatomy it will be necessary to examine the characters of the polypidom, and to trace its relationship to the polype.

The polypidom of *Plumatella Allmani*, Pl. V. figs. 3, 4 & 5, and of *Fredericella sultana* is tubular, branched and carinated on the upper surface; the walls opake, tough and membranous, inclining to horny. Those of the latter, when examined through the microscope, exhibit a sort of dendritic structure; the divisions or branches passing in an irregular spiral direction round the tube, are flattened, and extensively anastomosing form for the most part a dense tissue, nowhere more open than just to display the branched character. The walls of *Plumatella* do not in the least exhibit this structure. In *Paludicella* the polypidom, fig. 2, is likewise branched and tubular, but not carinated; it is membranous or horny, and becomes enlarged and contracted at certain intervals, dividing the whole, as it were, into cells or compartments, the external surface being smooth and very glossy.

All these genera have the polypidom lined with a delicate membrane—the tunic, Pl. III. figs. 4 *b*, *b* & 5 *k*, and Pl. IV. fig. 1 *b*, which is attached only at certain points to the inner surface of the external tube or cell-wall. This in *Plumatella* and *Fredericella* becomes excessively delicate towards the orifice, where it apparently blends with the tunic. But in *Paludicella* the union at this point of the horny wall and tunic cannot be mistaken, though the blending is so gradual that it is impossible to say where one ends and the other begins. And when this polype is exserted, there is a delicate membranous cup, Pl. IV. fig. 1 *d*, projecting upwards from the inner surface of the mouth of the cell. This cup is the homologue of the circle of setæ surrounding the aperture of *Bowerbankia* and other marine genera. In *Paludicella* the tunic is sprinkled with large nucleated cells, fig. 4 *m*, and at certain intervals bends abruptly inwards, figs. 1 & 2 *u*, *r*, dividing the polypidom into cells at the points indicated by the constrictions in the horny tube. Thus each polype is isolated, is contained in fact within a distinct membranous cell, the end-walls of which abut against the end-walls of the adjoining cells. The divisions are therefore double, and being of living membrane and in contact, it is probable that all the inhabitants of the polypidom are in some degree connected in vital action. The end-walls are considerably thickened in the centre, forming a bulb or boss projecting into the cell. The polypes of *Fredericella* are not separated the one from the other, though a few divisions appear to exist at distant points. Thus it would seem that groups of animals are associated together as it were in one tube. Neither in *Plumatella* are the polypes separated.

The polype lies in the longitudinal axis of the cell, Plates II. & IV. figs. 2, 2, being provided with numerous muscles for protrusion and retraction. It is held in its place principally by a membranous tube—the tentacular sheath, Pl. II. fig. 2 *m*, *n*, and Pl. IV. fig. 2 d', d', which blends with the inverted lips of the tunic, Pl. II. fig. 2 *l*, a little below the orifice of the cell, and continuing downwards within the cell incloses the bundle of retracted tentacles, and is attached round the tentacular disc a'.

Digestive System.—The organs of digestion, comprising nearly the whole of the polype, float freely in the visceral cavity. The entrance to the alimentary canal is furnished with tentacles, Pl. II. fig. 1 *b*; these arise from a margin surrounding the oral opening in two different fashions; in the one they form a complete circle round the mouth, in the other they are arranged in a crescentic manner, the limbs of the crescent being two arms, Pl. III. figs. 1, 2 & 3 *c*, *e* & *c*, extending from the sides of the mouth, fig. 3 *a*, having their bases confluent and with a row of tentacles on their inner and outer margins. *Paludicella* and *Fredericella*, Pl. IV. fig. 1 *f*, and Pl. II. fig. 1 *b*, are examples of the first mode of arrangement; and *Plumatella*, Pl. III. figs. 1, 2 & 3, and *Alcyonella* of the second. In *Paludicella* the tentacles when spread out form a very exact inverted cone, closely resembling the shape they assume in some of the marine species. The base or disc supporting the tentacles is not exactly circular in *Fredericella*; in this genus it is a little flattened at the point corresponding to the space between the oral arms in *Plumatella*; and there is also a delicate transparent membrane, Pl. II. fig. 1



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J. Basire, sc.

c', c, uniting the bases of the tentacles. In these respects *Fredericella* shows an approximation to those with oral arms, or as it is generally termed, a crescentic disc. In these there is always a similar membrane, Pl. III. figs. 1, 2 & 3 *e*, *f* & *d*, at the base of the tentacles, and in all of them, as well as in *Fredericella*, this membrane is attached to the external surface of the tentacles, and is much wider at the margin than the spaces between them, and consequently it bags out, giving to the upper portion a flounced appearance, particularly in the latter, Pl. II. fig. 1 *c*.

The tentacles themselves in all these genera are rather stout and linear with the end obtuse; they have the appearance of being tubular, as have likewise the oral arms of *Plumatella*: the tentacles are clothed with long cilia, which vibrate upwards on one side and downwards on the other in the same manner as described in the marine species; and as in them, when the polype is retracted the tentacles are drawn down in an erect position, having first been brought together into a compact linear bundle, Pl. II. fig. 2 *a*, and Pl. IV. fig. 2 *d*. They do not appear to be at all contractile, and in all the species are transparent and almost homogeneous in their structure. There can be little doubt that they are not merely tentacles, but that they are likewise respiratory organs: food is brought to the mouth by their ciliary currents, and also by the action of the tentacles themselves, one or more of which may frequently be seen bending suddenly inwards, and securing such particles as come within their reach. They occasionally act in concert in the capture of animalcules by bringing their tips together, thus forming, in those with a circular disc, a very elegant oval cage, within which the imprisoned prey may be seen for an instant or two dashing about previously to passing into the œsophagus or to liberation, which not unfrequently happens, the captive proving distasteful to the polype. The tentacles then may be considered prehensile labial or oral appendages, notwithstanding their respiratory function, and as such they are a portion of the alimentary system.

The oral orifice of *Plumatella* is semicircular, Pl. III. fig. 3 *a*, and protected by a strong, rounded, fleshy valve, *b*, which, arising from the side of the mouth at the point on the inner margin of the crescent where the two arms unite, projects upwards and slightly overhangs the opening. This valve is completely under the control of the animal, and can be made to act as a sort of operculum, closing the orifice to prevent the admittance of food; or it can be used to force food into the pharynx. The mouth, Pl. II. fig. 1 *d*, of *Fredericella* is likewise semicircular, and is also provided with a similar valve, *e*. It is immediately behind it that the tentacular disc is a little flattened, proving that this point corresponds to the space between the arms in *Plumatella*; indeed in some points of view the angles formed by this flattening have not a little the appearance of rudimentary arms just sprouting.

The œsophagus descends at once in a straight line from the oral opening. In *Fredericella*, Pl. II. figs. 1 *f* & 2 *b*, it is rather short and wide, and the walls, which are thick and fleshy, are parallel throughout, except at the commencement, where they are a little bulged, forming a sort of pharynx which is lined with vibratile cilia: the other extremity communicates with the stomach by a distinct valvular orifice, Pl. II. figs. 1 *g* & 2 *c*,—the cardiac, projecting downwards. The whole surface is covered with minute circular cells resembling very much the peculiar structure observed in the marine species, and pointed out by Dr. Farre in his valuable paper on the Marine Ascidian Polypes published in the 'Philosophical Transactions' for 1837.

The stomach, figs. 1 *h* & 2 *d*, is more than twice the length of the œsophagus, tapering slightly downwards and truncate above; the lower extremity being obtuse: the walls, like those of the œsophagus, are thick and fleshy, and are covered with numerous, minute, close-set cells of a glandular character. The pyloric orifice is circular and well marked, and has the appearance of being guarded by a sphincter muscle; it is likewise supplied with vibratile cilia which extend some little way into the stomach. This orifice is situated above, at one side and a little below the cardiac opening. The intestine, figs. 1 & 2 *i*, *e*, is straight, and a little longer than and nearly as wide as the œsophagus, with which it lies in contact and to which it is apparently attached; the pyloric extremity is obtusely pointed, and communicates by the side with the stomach; from thence the intestine tapers a little upwards towards the anal extremity, which, turning outwards, passes through the tentacular sheath just below its attachment to the disc supporting the tentacles, and there terminates in an obtuse perforated point, figs. 1 & 2 *j* & *f*, which can be either protruded or retracted to a considerable extent at the will of the animal. The whole of the alimentary canal is highly irritable, particularly the œsophagus and stomach, in the walls of both of which, minute, transverse striæ are distinctly visible, probably indicating the presence of muscles. The stomach is perpetually in motion when the animal is displayed, contracting in an undulating or vermicular manner from above downwards. The contractions of the œsophagus, too, are very decided on receiving food, which for a second or two rests in the pharyngeal enlargement, and is then hurried to the stomach with great rapidity.

The alimentary canal of *Plumatella* and *Alcyonella* does not vary in any important manner from that of *Fredericella*. In the two former, however, both the œsophagus and stomach are shorter than they are in the latter genus.

In all these genera no disturbance of the parts of the alimentary canal takes place on the retraction of the polype: the animal sinks into the cell with the œsophagus, stomach and intestine erect as they were when the tentacles were exserted and in full play. Not so however in *Paludicella*, Pl. IV. fig. 2; in this genus the alimentary canal is doubled upon itself when the polype is retracted; and moreover the parts are somewhat modified, approximating this form more closely to that of the marine species.

When the animal of *Paludicella* is protruded, the œsophagus, fig. 1 *h*, is observed to be long and slender, and to have a distinct pharyngeal dilatation at the commencement, where vibratile cilia can be seen in vigorous action. It communicates with the upper extremity of the stomach by a circular orifice, fig. 2 *f*. The stomach, fig. 1 *i*, is rather short, considerably enlarged above and tapering to the inferior extremity, where it is rounded: the walls are thick, and apparently filled with yellowish brown coloured granules, probably hepatic as in the marine species. The intestine, *j*, arises from the superior extremity close behind and a little above the cardia. The pyloric opening is well defined and circular; soon after its origin the intestine is suddenly enlarged, forming an oval swelling, *k*, in which the fæces may be seen collecting; it contracts above this swelling, and continues afterwards for nearly its whole length of equal diameter; it passes upwards in a straight line parallel with the œsophagus, but unattached to it, and terminates in a rounded anal extremity, *l*, immediately below the base of the tentacles where it perforates the tentacular sheath. The upper end of the stomach, close to the pyloric orifice, is furnished with vibratile cilia, and here the alimentary matters may be seen rapidly rotating by their influence. The fæces are formed into small pellets, which, coming from the enlarged portion, pass up the intestine and are expelled at the anal orifice. The whole of the canal is as highly irritable as in the other species; the stomach undulating from above downwards in the same manner, and the œsophagus is equally expert in transmitting food to the stomach. But neither in *Paludicella* nor in the species before alluded to does the pharyngeal swelling exhibit in any marked manner the sudden puffings and contractions so conspicuous in the marine species, and noticed originally by Dr. Farre.

On retraction of the polype, the alimentary canal of *Paludicella* is doubled upon itself in much the same way as in *Bowerbankia*. The basal disc of the tentacles is then brought down as far as the upper extremity of the stomach, and the consequence is that the intestine, fig. 2 *h*, is doubled upon itself a little above the enlargement, *i*, and the œsophagus, *e*, is forced down by the side of the stomach, *g*, and turning upwards again is bent into the form of an S.

Vascular System.—This appears to be entirely wanting in these animals: a species of circulation nevertheless exists. I have seen on two or three occasions a pretty regular flow of the fluid in the visceral cavity of *Plumatella* and *Fredericella*. Under ordinary circumstances no fluid can be recognized in this cavity, from the apparent deficiency of blood-globules or corpuscles of any kind. Such however probably exist, but the thickness and opacity of the cell-walls are sufficient to prevent the detection of minute bodies of this nature. On the occasions alluded to some of the tissues of the animal appear to have been ruptured, and small fragmentary particles mingling with the contained fluid were perceived moving in certain directions. By the aid of these particles, which were numerous and of various forms and sizes, it was easy to ascertain that the fluid which bathes the polype circulates in a regular manner within the cavity in which the viscera float. There can be no doubt that this circulation is caused by the action of cilia which cover the inner surface of the lining membrane or tunic, and also clothe the external wall of the retracted tentacular sheath. The current flowed regularly and steadily; but when the floating particles approached the surface of the tunic or tentacular sheath, their motion became accelerated in a manner that sufficiently evinced the presence of vibratile cilia. Those on the tunic chiefly determined the direction of the current, which went with great regularity up one side, crossed over at the top of the cell, and then went down the other side; it crossed again in an opposite direction a little below the stomach, and so completed the circuit. It was not difficult to ascertain that the cilia of the tunic on one side of the cell vibrate upwards, on the other side downwards; and that all those on the tentacular sheath vibrate upwards. On one side therefore the currents of the sheath and tunic oppose each other; and consequently an eddy was visible near the top of the cell.

It is quite evident then that fluid circulates within the visceral cavity. What is the nature of this circulation? Is it merely respiratory, or is it nutritive? It can scarcely be considered an aërating current, as there is no visible communication between this cavity and the external water; and indeed if an orifice exists, it must be minute and under the control of the animal, or the protrusion of the polype could not be effected in the manner to be afterwards described. It is more likely to be for the purpose of nutrition,—standing, indeed, in the place of a vascular system.

The fluid must therefore hold in suspension the products of digestion. These may be supposed to exude through the walls of the intestinal canal, probably from the enlarged portion of it in *Paludicella,* and perhaps also from the upper portion of the stomach; and passing into this circulation will go at once to nourish the various organs of the animal, all of which are bathed with this vivifying fluid, except the tentacles, which we shall afterwards see, in all probability, receive blood into their interior for the purpose of aëration. In this way, too, we can understand the nourishment and growth of the tunic and the maintenance of the buds (which germinate from it) until they are able by the aid of their own tentacles to procure food. In no other way can the development of these buds be so easily explained. The membrane in which they take their origin must either be supplied with the nutritive fluid in this way or by the agency of vessels; but none can be discovered either in the tunic or elsewhere. The external cell-walls whilst in a growing state must also be nourished by the tunic, which we have seen is united to the external walls at the orifice of the cell.

The respiratory function we have stated to be exercised by the tentacles, but there can be no doubt that all the exposed parts will assist in aërating the blood. The tentacles are hollow, and though I could not detect any fluid within them, it is probable that the blood finds its way into their tubular cavities through the basal disc; and as they are clothed with strong vibratile cilia which keep a constant flow of the oxygenating medium over their surfaces, they would appear well adapted for breathing organs. It is however difficult to understand how the oxygenation of the blood goes on when the polype is retracted; for at this time the orifice is completely closed by the folding in of the lips of the cell, and by muscles provided for the purpose. Professor Allman has supposed that the tube retractors of *Paludicella* exercise the function also of opening the aperture when in this state for the purpose of admitting the surrounding fluid. But I have seen nothing to warrant such supposition; and indeed the tentacles being then packed close together within the sheath, the cilia cease to vibrate, and there is no room in which the water can flow around them, even supposing an opening to be so maintained. The tips of the tentacles too of *Paludicella* and of several of the marine species when retracted are generally bent down in a manner to forbid the flow of any fluid whatever amongst them. It would therefore seem clear, that when not in action the oxygenation of the blood must almost, if not entirely, cease in these polypes, as it must do in most of the Mollusca when closed up in their shelly armature.

Nervous System.—Some years ago Professor Allman discovered a ganglion in these animals, and has more recently ascertained the existence of nerves. I have also detected a large ganglion, Pl. II. fig. 1 *k*, in *Plumatella* and *Fredericella*. It is situated just below the entrance to the œsophagus on the external surface, close to the base of the tentacles and just above the anal orifice. It is therefore placed between the oral arms in *Plumatella*, and in *Fredericella* at the corresponding point. In the latter I have observed two or three nerves passing from the ganglion upwards in the direction of the tentacles, and one apparently going to embrace the œsophagus; another that comes from the lower extremity of the ganglion may also be seen passing downwards close to the œsophagus. This is all I have been able to make out respecting the nervous system, though undoubtedly more is to be learnt.

Muscular System.—There are three distinct sets of muscles in *Plumatella* and *Fredericella*; one for the retraction of the polype, another to assist in the act of protrusion, and the third probably accessory in closing the orifice. The first and most conspicuous set of muscles, the polype retractors, Pl. II. figs. 2 *g*, *g* & 4 *f*, and Pl. III. figs. 4 *g* & 5 *i*, *i*, is divided into two equal bundles, one passing on each side of the polype. These bundles are composed of numerous, stout, isolated fibres, having their origin in the walls of the cell a considerable way below the retracted polype; and passing upwards have their superior extremities inserted at the tentacular disc or base of the oral arms and at the upper portion of the œsophagus. There are also two similar bundles of muscular fibres in *Alcyonella*, but in this genus they have their origin at or close to the bottom of the cell. When the animal of *Plumatella* is exserted, two or three of the stoutest, Pl. II. fig. 4 *g*, of these fibres are seen to be attached on each side further forward than the rest at the base of the oral arms. Also in *Fredericella* similar fibres are inserted at the corresponding parts of the tentacular disc. These stout fibres have their origin a little lower down the cell than the rest.

The function of these two bundles of muscular fibres cannot for a moment be mistaken: they are for the purpose of drawing the polype back into the cell; and when it is so withdrawn, the fibres of this, the most powerful muscle of the animal, may be seen in a relaxed state and bent upon themselves in a loose undulating manner about the tentacular disc and downwards to their origin. The few strong fibres alluded to undoubtedly assist in the retraction of the polype; but are also apparently the principal agents in rotating the head, so to speak, of the polype when exserted.

The second set of muscles, Pl. II. figs. 1 & 2 *m*, *h*, is composed of a circle of stout, isolated, radiating fibres, all placed in the same horizontal plane, considerably apart from each other, and attached by their outer extremities to the inner surface of the tunic some way below the opening; their inner extremities converging towards the tentacular sheath are attached to it about one-third from its superior termination. *Plumatella* has fifteen or sixteen of these fibres, *Fredericella* about fourteen. Their arrangement is perfectly symmetrical. They are for the purpose of preventing the inversion of the whole of the tentacular sheath on the protrusion of the polype; and thus to confine the oral extremity within a convenient distance above the mouth of the cell.

The true value of these muscles will be fully understood if we refer to the marine genus *Bowerbankia*, in which they are deficient, and of course the tentacular sheath can be completely inverted, and accordingly the animal is enabled to reach to a greater distance than it could otherwise have done. But an apparatus of extraordinary beauty is provided to obviate the inconvenience that must have arisen from the great elevation of the tentacular disc above the support of the horny cell. This is effected by what may be considered an elongation upwards of the cell. Numerous setæ bound together by a membrane are attached to the lips of the orifice, so that when the polype is exserted they stand up in a circle surrounding the lower part of the exposed portion of the animal and give support to it. By this means the far-outstretched tentacular disc is brought completely under the control of the muscles for directing its movements*. We thus clearly see that this set of radiating muscles is a compensation for the deficiency of the circle of setæ in the freshwater polypes.

The third set of muscles, figs. 1 & 2 *n, i*, consists of numerous, separate, fine thread-like filaments placed considerably apart, without order, but in the same radiating manner as those last

* Dr. Farre has described this apparatus in his paper so frequently referred to, but seems scarcely to have arrived at a full knowledge of its function. He considers that it is "for allowing of the freest possible motion to the upper part of the body in its expanded state, to which it affords at the same time support and protection." On examining the animal in action it is evident that the use of the apparatus is as I have pointed out. The circle of setæ is then seen to compress the lower portion of the extended polype; and when the tentacular disc moves from side to side the neck always bends from the top of the setæ at a decided angle, and does not gradually arch away from the lips of the cell as might be expected were this contrivance for the purpose of giving flexibility. The delicate membrane uniting the setæ is strengthened with numerous, minute transverse fibres, forming the whole into a powerful sphincter, thus giving great firmness to the part. By this arrangement *Bowerbankia* is enabled to raise the tentacular disc far above the polype-cell, and yet to remain as perfectly under the control of the rotatory and retractor muscles as is the tentacular disc of *Fredericella* and *Plumatella*, in both of which it is confined close to the orifice of the cell by the action of the radiating muscular fibres.

described, immediately above them and extending upwards to the termination of the cell. These filaments have their outer extremities attached to the inner surface of the tunic; and converging towards the axis of the cell, their inner extremities are attached to the upper portion of the tentacular sheath and the inverted margin of the tunic. These fibres are equally numerous and fine in both *Plumatella* and *Fredericella*, and appear to be for the purpose of assisting in closing the orifice, acting in harmony with the contraction of the upper portion of the tentacular sheath and the inverted lips of the orifice. They may, acting in the opposite direction, also assist in opening the channel, but the tentacles themselves would appear quite adequate to force a passage on the relaxation of the contractions about the orifice. The function of these fibres is in fact to keep in unison the tunic near the opening and the upper portion of the tentacular sheath.

The upper portion of the tentacular sheath and inverted lips of the tunic are highly contractile, and it is by their agency principally that the orifice is closed when the animal is retracted. I have not however been able to detect any muscular fibres for the purpose, though at the point, Pl. II. fig. 2 *n*, where the inverted lips of the tunic join to the tentacular sheath, it is suddenly constricted as if by a powerful sphincter muscle. In fact the whole of the tunic is undoubtedly contractile, yet in no part of it have I detected muscular fibres. By the contraction of this lining membrane the capacity of the visceral cavity is diminished; and thus by the pressure of the contained fluid the protrusion of the polype is effected. This matter however will be discussed more fully when we come to speak of this portion of the anatomy of *Paludicella*.

To understand the combined action of the various sets of muscles in *Plumatella* and *Fredericella*, we have only to watch the animal when about to issue from the cell. The first change observed is the contraction of the tunic, Pl. II. fig. 4 *j*, *j*, and Pl. III. fig. 4 *b*, the walls of which are brought nearer together towards the lower portion of the cell. The pressure thus occasioned on the contained fluid compels the polype to begin its ascent; at the same time the sphincter contraction of the upper portion of the tentacular sheath relaxes, so that the bundle of tentacles can force their way without difficulty. As the polype gradually advances upwards the circle of strong radiating muscles comes into play, and it is a sight of no little interest to watch them drag upon the tentacular sheath, allowing the inferior portion of it to roll upwards attached to the tentacular disc. As soon as the ascent is arrested by these muscles, the sheath being inverted as far as they will permit, protrusion is complete, and the tentacles at once assume their proper arrangement.

The muscular apparatus of *Paludicella* differs in some respects from that of *Plumatella* and *Fredericella*. In the former there are six sets of muscles—three in connexion with retraction, two with protrusion, and one for closing the orifice on the retreat of the polype. Of the retractors one set acts directly upon the animal, the other two upon the tubular orifice of the cell. The former set, Pl. IV. fig. 1 *o*, the most powerful in the animal, is similar to the tentacular retractors of Dr. Farre: it differs only from the polype-retractors in *Plumatella* and the other genera already spoken of in not being divided into two bundles. It is composed of numerous, stout, long, linear fibres originating from the inner surface of the anterior wall of the cell more than halfway down; then passing up in front of the polype the superior extremities are inserted around the base of the tentacular disc. These fibres draw the polype down into the cell, and like those of the same muscle in the other *Bryozoa*, when unemployed lie in a somewhat cramped and disordered state, fig. 2 *l*, *l*.

The second and third sets of muscles are the tube-retractors; the former or inferior, figs. 1 *p* & 2 *m*, *m*, is much the larger; it is composed of four compressed bundles of stout, linear fibres placed close together, but distinct from each other. These bundles are associated together in pairs, one on each side of the tube; the inferior ends of these pairs of bundles arise wide apart from the posterior wall of the cell opposite the orifice. As they pass up the tube the bundles converge, and reaching within a short distance of the lips of the orifice, they are inserted upon the inner surface of the tube-walls at four opposite points; the fibres of each bundle being attached one above the other in the same longitudinal plane. This peculiar arrangement causes the margins of the orifice to fold into four portions on the retraction of the tube; and its end, fig. 3, consequently assumes a square form, the angles corresponding to the insertions of the muscular bundles.

The third set of muscles, figs. 1 *q* & 2 *n*, *n*, the superior tube-retractors, are made up of only four fibres, two on each side of the cell, having their origin immediately below that of the set just described; their other ends are attached to the inner surface of the tube above the insertion of the inferior set, and at the base of the membranous cup, fig. 1 *l*, before alluded to, at the mouth of the cell. The inferior and superior tube-retractors are homologous to the double set of opercular muscles described by Dr. Farre in the marine species, differing only from those in *Bowerbankia densa* by being divided into four bundles instead of into three as they are in that species. The action of these muscles is obvious. The superior retractors, having their insertion at the base of the membranous cup at the mouth of the cell, draw it down base first in the axis of the tube, at the same time folding in around it the lips of the cell. The inferior set then taking up the work complete the inversion of the tube. Dr. Farre, however, supposed that the opercular muscles were not merely for drawing the tube in after the retreating animal, but also for the purpose of closing the orifice. Professor Allman has pointed out the error of this opinion, and endeavoured to explain the closing of the orifice by the pressure of the fluid within the cell against the walls of the inverted tube. We shall directly see, however, that this theory is unnecessary, there being special muscles provided for the purpose. Professor Allman is likewise disinclined to believe that the opercular muscles are really tube-retractors, as he supposes the muscles for drawing in the polype are sufficient for the purpose also of drawing in the tube. Were these latter muscles used to invaginate the tubular orifice of the cell, we should expect to find them in action so long as the animal was retracted; but we have already seen, that when the polype is in this state, they are invariably relaxed and lie in a disordered undulating manner, perfectly at rest. The tube-retractors on the contrary are always tense and in vigorous action during the retracted state of the polype, evincing I think in a satisfactory manner that their function is to retract the tube and to maintain it in an invaginated state,—unless we are to suppose that they are constantly employed in keeping open the channel as suggested by Professor Allman. They will certainly have a tendency to pull asunder the walls of the inverted tube, yet I have never seen the channel thus opened, although these muscles are never otherwise than as represented in Pl. IV. fig. 2, when the polype is retracted. And moreover the tips of the tentacles, as exhibited in this figure, are frequently doubled down, showing that the tentacular sheath must be to some extent relaxed, and that there is no stress whatever on it, as there would be were the polype-retractors used to draw in the orifice.

The fourth set of muscles to be described is for closing the orifice. This set is composed of two sphincters: one, fig. 2 *o*, of these is made up of several fibres passing round the tube at the place of insertion of the inferior tube-retractors, and is of considerable breadth; the other, *p*, is formed of only two or three fibres, which encircle the same tube at the insertion of the superior tube-retractors. The action of these sphincters cannot be mistaken; they effect the closing of the orifice on the retraction of the animal; being at the same time antagonistic to the opening tendency of the tube-retractors, which, diverging from their insertions, must in some measure bring the walls of the inverted tube asunder. These sphincters are not readily distinguished, but having seen them in several individuals, I have not the slightest doubt of their existence. Deeming however that it would be satisfactory to see whether a similar apparatus for closing the orifice could be found in the marine species, I examined specimens of *Bowerbankia*, and had the satisfaction of detecting sphincter muscles in the same situations. At the point of insertion of the inferior tube-retractors—according to Dr. Farre of the upper set of opercular muscles—the circular fibres are very distinct and numerous, forming a large portion of the inverted tube into a broad sphincter. These fibres are so conspicuous that it seems strange how they could have escaped the notice of so close and accurate an observer as Dr. Farre. It is possible enough, however, that they might be less developed in the species examined by him*. The sphincter at the point of insertion of the superior tube-retractors is not readily observed; but when the polype is exserted there can be no doubt of its existence.

The fifth set of muscles, figs. 1 & 5 *t, h*, is in connexion with the tunic or lining membrane of the cell, and is precisely similar to the parietal muscles described by Dr. Farre in the marine species. This set is formed of short, transverse belts, arranged in pairs, considerably apart from each other, which are to be found almost from end to end of the cell, but most conspicuously towards the lower extremity. There appears to be two sets of these fibres, one down the back, the other down the front of the cell; but I could not arrive at any very satisfactory conclusion respecting their arrangement, neither could I determine their exact relationship to the tunic,—whether they are attached to it by their extremities only as supposed by Dr. Farre, or connected with it throughout their entire length. Professor Allman appears to be of the latter opinion, and certainly I saw nothing in confirmation of that expressed by Dr. Farre; though I am not sure that the extremities are not attached to the cell-walls, thus giving to these muscular belts fixed points of action. Howsoever this may be, these parietal muscles undoubtedly have the power of contracting the tunic, and so lessening the space within which the polype is confined; the contained fluid is made to press on the surface of the polype, constraining it to pass upwards, and thus to effect its

* In the species examined by Dr. Farre and named by him *Bowerbankia densa*, the tube-retractors have a "triradiate arrangement," and consequently the orifice is puckered into three folds when the polype is retracted. The species referred to in the text we have seen has four such folds—the tube-retractors being divided into as many bundles. The circle of tentacles also assumes a different form in the two species: in that examined by me the tentacles rise from the disc in a straight, slightly diverging line, and arch considerably outwards at the tips. In Dr. Farre's species they arch outwards immediately above the disc, and are very little recurved at the tips. It is therefore pretty evident that there are two species, and that *B. densa* should not be merged in *B. imbricata*, which is most probably the form that I have seen.

protrusion much in the same manner as in *Plumatella* and *Fredericella*. In these however there is some little difficulty, the cells being continuous; but in *Paludicella*, in which they are all separated, this act can be clearly understood. I have certainly observed in *Plumatella* and *Fredericella* the appearance of divisions here and there, forming as it were the cells into groups or systems, but nothing to warrant the belief that each cell is isolated. It might therefore be thought that protrusion of a few of the polypes would necessitate that of the others, or at least would cause an inconvenient pressure on the other members belonging to the same group.

It is difficult to arrive at a full explanation of the propulsion of the polype in these cases; but there can be no doubt that in them, as in the other *Bryozoa*, the contraction of the tunic is the sole agent. Dr. Farre believed that the act of protrusion did not so much depend on the contraction of the tunic as on the straightening of the alimentary canal, which in the marine species and in *Paludicella* is doubled upon itself when the polype is retracted. But in *Plumatella, Fredericella,* and *Alcyonella* it is always straight; in these genera, therefore, protrusion cannot in the least be assisted by the alimentary canal. Professor Allman has referred to this fact to prove the error of Dr. Farre's opinion; and indeed, if it be allowed, and I suppose it must, that the pressure of the fluid maintains the protruded animal in its position, it is more than probable that the same power would be sufficient to perform the act of protrusion. From the movements of the alimentary canal it is pretty evident that it has the power of straightening itself: but when quite straight only a portion of the tentacles would be protruded beyond the cell; and here they would remain, for it is very clear that whether straight or bent, the alimentary canal will displace the same quantity of fluid, and that there would be no increase of pressure to force the animal upwards. It is at the moment when the alimentary canal is being straightened that the parietal muscles come into play, and compel the animal to rise above the cell: these acts are perfectly simultaneous. The protrusion therefore of the polype with a bent œsophagus and intestine is effected in the same manner as that in which these organs are straight; only that in the former it is accompanied with the straightening of the alimentary canal.

The sixth and last set of muscles to be described is for the purpose of preventing the entire eversion of the tentacular sheath. This set, Pl. IV. figs. 1 *r*, *r* & 2 *q*, *q*, is the homologue of the strong radiating muscles in *Plumatella* and *Fredericella*; but the fibres are much less numerous. In *Paludicella* they are only four in number, and take their origin from the inner surface of the cell, two in front immediately below where the tube joins the cell, and two behind in a line with the upper wall of the tube; hence the fibres are placed in front of and behind the polype, and are inserted into opposite points of the tentacular sheath a little way below its summit, having on each side of them the two bundles of the tube-retractors. In the retracted state of the polype these fibres are seen passing downwards towards their insertion. When the polype is protruded these muscles cause the sheath to double upon itself, and thus retain a portion of it within the tube; but not to the same extent as in *Plumatella* and *Fredericella*. It has already been pointed out that in these genera this set of muscles compensates for the want of the circle of setæ which surmounts the orifice in the marine species. In *Paludicella*, however, we have already seen that there is a wide, delicate, membranous cup which rises from the inner surface of the tube a little within the orifice. This cup is undoubtedly the homologue of the circle of setæ alluded to, but in a very rudimentary state, and probably of little or no functional utility: consequently these muscles are still present, though, as might be expected, not so fully developed as in those genera entirely deprived of this appendage.

We have now gone through the whole of the muscular apparatus for retraction and propulsion, and to verify the use of the various sets of muscles, we must once more observe the animal while issuing from the cell. The first symptom indicative of the polype's inclination to come forth is the contraction of the parietal muscles, causing the tunic in certain places to leave the walls of the cell, particularly towards the lower portion; on this the polype commences to move up the cell, and at the same instant the tube-retractors relaxing the inverted lips of the orifice begin to be evolved, and as the contraction of the parietal muscles goes on the polype advances upwards, and more and more of the tube is turned out, in the manner of the eversion of the horn of the common snail; at length the membranous cup makes its appearance, not doubled upon itself, but in an erect position—the margin first, just as the circle of setæ is exserted in *Bowerbankia*. The cup at first is laterally compressed, having been packed longitudinally in the axis of the tube: the tips of the tentacles now emerge through the centre of this cup, and as they pass upwards pressed together in a line side by side, its lateral folds give way, and by the time that the tentacular disc has reached the mouth of the cell, the cup is perfectly expanded. The muscles preventing the entire eversion of the tentacular sheath may now be seen in action near the upper extremity of the tube, holding back the membranous sheath and causing it to roll upon itself. The polype is now fairly above the mouth of the cell, and as the tentacles expand it has attained its greatest elevation; the cilia then commence to play, and all kinds of particles are hurried towards the mouth.

The retraction of the polype is instantaneous, so rapid indeed that it is quite impossible to follow with the eye the actions of the muscles;—such is the velocity with which this feat is performed, that from complete protrusion to invagination nothing can be perceived but the settling of the polype upwards, after having apparently been dragged too far down the cell. It is not difficult however to understand how the act of retraction is accomplished; the operation of the muscles will be reversed. First the parietal muscles must relax, allowing the tunic to assume its place close to the cell-walls; at the same instant the polype-retractors will contract, and as the animal sinks into the cell the superior tube-retractors will also contract; next the inferior tube-retractors will come into play; and finally, after retraction is complete, the sphincters will close the orifice.

On comparing the muscular system of the freshwater *Bryozoa* with that of the marine forms, a great similarity is observed; some interesting modifications however are deserving of notice. The most remarkable of these are found in connexion with the orifice. In *Plumatella* and *Fredericella* there is no tubular inversion on the retreat of the animal; the tunic is certainly doubled upon itself for a short distance within the orifice, but it remains permanently so. *Paludicella* on the contrary has the walls of the tubular orifice invaginated to a considerable extent when the polype is retracted, and when protruded nearly the whole is evolved. But *Bowerbankia* and other marine forms differ from the freshwater species in having the mouth of the cell completely unrolled when the polype is protruded, the same having been invaginated to a great extent when it was retracted. Thus in the first and last modifications we see the extremes of variation, and consequently the most extensive alterations in the muscular arrangements of these parts. *Paludicella* being in a middle state has the muscular apparatus to some extent of both; and in this respect connects the freshwater with the marine forms.

The tube-retractors are wanting in *Plumatella* and *Fredericella*, and are present in *Paludicella* and in all the marine species, being most developed in the latter. Neither in these nor in *Paludicella*, however, is there anything like the small radiating muscles near the orifice in *Plumatella* and *Fredericella*; and the marine species, too, are destitute of the large radiating muscles in connexion with the tentacular sheath. These, though present, we have seen are less developed in *Paludicella* than in *Plumatella* and *Fredericella*, the former resembling *Bowerbankia* in having a cup at the mouth of the cell. The polype-retractors are very similar in all the *Bryozoa,* only those at the inferior extremity of the stomach in the marine species appear deficient in the freshwater forms. They all have, however, one or more appendages to this part, but these we shall afterwards see are most probably connected with the reproductive system. The parietal and sphincter muscles are common to both *Paludicella* and the marine forms. On the whole, then, in the muscular system as well as in the digestive apparatus, *Paludicella* shows a close relationship to *Bowerbankia* and its congeners; and is, in fact, an intermediate link between them and the other freshwater *Bryozoa.* Even the minute structure of the muscles themselves would seem to confirm this. In all they are composed of transparent, linear fibres separated from each other and apparently homogeneous. When broken they become irregularly nodulous; but I have not succeeded in detecting transverse striæ observed by Professor Allman, probably from having used insufficient magnifying powers. The small knot-like swelling so remarkable in the centre of the fibre of the marine species is not to be found in either *Plumatella* or *Fredericella*; in *Paludicella,* however, I have observed it in the parietal, but in no other muscles.

Reproductive System.—In the freshwater as in the marine *Bryozoa* there are two methods of reproduction,—one by buds, the other by eggs. The buds always germinate from the same part of the cell, hence the definite form of the polypidom. In *Fredericella* the germ is found in connexion with the inner surface of the tunic not far below the orifice of the cell on its lower side. As the bud enlarges the wall bulges, showing externally the appearance of a new shoot. At first the bud, Pl. II. fig. 3 *a,* is small and oval, and is attached for nearly its whole length; it, fig. 2 *o,* soon becomes irregular in form, with the upper portion broad and somewhat bifid, the lower extremity prolonged: the upper portion then gradually exhibits a circle of short rudimentary tentacles, fig. 4 *l*; and the lower end is seen to be divided longitudinally into œsophagus and intestine, fig. 5 *b, d,* continuous at their lower extremities, which still elongating form the stomach, figs. 4 *m* & 5 *c.* To this is seen an appended filament binding it below to the wall of the cell. Imbedded in this filament there is a large, distinct globule with nucleus and nucleolus: this we shall afterwards learn is the incipient ovum, figs. 4 *o* & 5 *e,* lying in the ovary. The polype-retractors, figs. 2 *q* & 4 *n,* now make their appearance, passing from the tentacular base to the side of the cell formed apparently out of the lower portion of the original attachment of the bud; the upper portion of this attachment dilating becomes the tentacular sheath, fig. 2 *p,* into which the tentacles are gradually insinuated as they are developed. The polype being now, as it were, sketched out within the cell of the parent, its own chamber rapidly forms. and in the course of a day or two, the muscles in connexion with the orifice being added, the fresh-born member of the community bursts from the extremity of its cell, and is ready to take upon itself the work of its own maintenance.

The development of the bud in *Plumatella* differs in no respect from that of *Fredericella*; and in *Paludicella* there is no very important deviation, except at the commencement of the process. In this the first apparent step in the growth of a new polype is the preparation of a distinct cell for its reception. If the top of the last-formed cell be carefully examined, even before its tenant is fully grown, the lining membrane may be seen terminating in a blind sac, Pl. IV. fig. 4 *b'*, a little below the extremity. Within this extremity will also be observed a membranous sac, *l*; at first the base of this sac is moulded on the convex blind termination of the lining of the old cell. The convexity however soon flattens and the sac rapidly increases in size, the external horny covering becoming at the same time elongated and attenuated. After awhile, an oval, somewhat opake body, the new bud, fig. 5 *m*; germinates from the inner surface of the lining membrane, *l*. This body is attached by its side to the front wall of the cell, and resembles the young bud in *Fredericella*. A long and very delicate membranous sac, fig. 6 *d*, afterwards the tentacular sheath, is now observed to be forming in contact with and above the oval bud; whilst from the lower extremity filaments, *e*, are seen to be produced which form the polype-retractors. From the upper end of the bud, the tentacles, fig. 4 *d*, soon make their appearance within the lower part of the membranous sheath, *i*; at first very short, no more than the scalloped margin of the cup-formed disc; but rapidly lengthening, fig. 5 *a*, they soon advance more than halfway up the sheath. The polype-retractors, figs. 4 *j* & 5 *g*, by this time are considerably developed, and the retractors, *k*, *i*, of the tube are distinctly visible; the tube, fig. 4 *j*, now begins to bulge, and the inverted margins of the orifice are seen within, united to the upper end of the tentacular sheath: the parietal muscles, *h*, also make their appearance at this time, and the stomach, *c*, intestine, *d*, œsophagus, *b*, and tentacles having all assumed their proper forms, the young animal is ready for protrusion. The buds of *Paludicella*, however, do not all originate from the extremity of the old cell; some sprout from the side, and then a slight swelling takes place on the inner surface of the tunic. The horny sheath soon afterwards begins to bulge, and an external cell being formed with its lining membrane, an oval bud makes its appearance, and development goes on as just described.

It has been long known that these animals propagate by eggs as well as buds; Raspail appears to have described the anatomy of the egg and the hatching of it, and the subsequent growth of the young polype has been minutely investigated by Sir J. G. Dalyell. But the generative organ remained unrecognised until it was pointed out by Professor Allman. The appendage to the lower extremity of the stomach, considered by Trembley to be muscular, Professor Allman believes to be an ovary: that it is so there can be no doubt, as eggs may occasionally be seen in connexion with it. Appendages of this kind exist in *Alcyonella, Plumatella, Fredericella* and *Paludicella,* and will probably be found in all Ascidian polypes. In *Plumatella* and *Fredericella* there are however three of these appendages or filaments, Pl. III. figs. 4 *f, d, d,* & 5 *e, e′, h, h,* which are all attached to the lowest part of the stomach, and passing down have their other ends attached to the wall of the cell not far from the insertion of the polype-retractors. It is difficult to say whether all three are connected with the generative function, or whether some of them are not muscles for the retraction of the stomach. A bundle of such retractors has been described by Dr. Farre in the marine species, attaching the inferior end of the stomach to the base of the cell; but one of them is generally thicker than the rest, and may probably be connected with the reproductive system. *Paludicella* has two such filaments; one, Pl. IV. figs. 1 & 7 *n, g,* passing in the usual manner from the lower end of the stomach; the other, *m, d,* from the upper. These two filaments are inserted upon the posterior wall of the cell, one a considerable way above the other. When the polype is retracted these insertions are found to be a little above the gastric attachments, and the filaments, fig. 2 *j, k,* doubled upon themselves. These are thick, cylindrical and apparently tubular, and do not at all resemble muscles, and indeed, from the relative position of their attachments, they seem ill adapted for retraction.

In *Plumatella* and *Fredericella,* one, Pl. III. figs. 4 *d, d* & 5 *e, e′,* of the filaments is generally stouter than the other two, and this has frequently an egg, *e, f,* attached to it. When the ovum is much developed, it is difficult to make out its relationship to the filament or ovary; but when quite young, it has all appearance of originating from the interior. On one occasion I observed two eggs in connexion with the ovary, one almost mature, the other only forming. The former, fig. 5 *f,* was attached rather below the middle of the generative organ. When the polype was protruded, this organ dragged forward the upper end of the egg; the other end of it was then seen to be attached to the wall of the cell by the continuation of the filamentous ovary *e′*. A little below the egg there was a slight oval swelling, in the interior of which was seen a nucleated cell, *g,* undoubtedly an ovum in a very early stage of development, and apparently in the interior of the ovary*. In *Fredericella* a similar nucleated cell, Pl. II. figs. 4 *o* & 5 *e*, has been observed in the appendage to the stomach, while the polype was yet in a very rudimentary state, as exhibited in the bud before alluded to. In this genus I have likewise seen the ovum in a considerably advanced state, in which also its relationship to the ovary could not be mistaken. In this instance the lower portion of the generative organ had dilated into a sort of capsule, within which the egg, Pl. II. fig. 6 *a* & Pl. III. fig. 4 *e*, was enveloped. The portion of the ovary, Pl. II. fig. 6 *c*, below it was short and thick, having the appearance of a pedicle, by which the egg was fixed to the side of the cell; above the capsule, the ovary, c', was much thinner, contracting suddenly upwards. This would seem to demonstrate that the egg is developed in the interior of the ovary.

I have also seen what I take to be the ovum of *Paludicella*, but as it differs considerably from the egg of the other freshwater *Bryozoa*, we must not pronounce with certainty. This supposed egg was first observed in the cell of the dead polype; two or three occurred; they were attached to the upper portion of the interior of the cell. Afterwards one, Pl. IV. fig. 7 *e*, was found in connexion with the living animal, and in this case was fixed by a delicate membranous sac, *f*, to the side of the cell at the point of attachment of the filament coming from the upper end of the stomach, the base of the filament being apparently surrounded by the sac. This filament then, in *Paludicella*, is probably an ovary; and if so, the egg must pass in a very early stage from it into the membranous sac at its base, and there be matured. And, judging from analogy, the other filament is also probably connected with generation.

In *Plumatella* and *Fredericella* however there can be no doubt of the ovarian character of one of the filaments attached to the stomach; but the nature of the other two, Pl. III. figs. 4 *f* & 5 *h*, *h*, is not so easily determined. They certainly do not look altogether unlike muscular fibres; but from their attachments close to that of the ovary, and from their resemblance to it, they are most probably connected with the generative function. It may be that each filament is a separate ovary, or that one or two of them is the male organ. These polypes are most probably hermaphrodites—at least, in all the specimens of *Plumatella Allmani* that I have examined, there was scarcely a cell that did not contain one egg or more. It may therefore be presumed that each individual is provided with male and female organs. Dr. Farre discovered moving bodies in the visceral cavity of *Valkeria* and some other of the marine forms, and described them as re-

* I have also seen a similar nucleated cell in the enlarged filament from the lower end of the stomach of *Bowerbankia*.

sembling *Cercariæ*. I have detected similar bodies in *Bowerbankia* with large rounded heads and long tails; they were very numerous, and moved rapidly about in the interior of the cell in the manner of tadpoles, that is, with a lateral undulating motion, and are assuredly *Spermatozoa*. A testis may then be expected to exist in the freshwater *Bryozoa* coextensively developed with the ovary, and from analogy to be associated with it. It is not unlikely therefore that these additional filaments from the stomach may be really the male organ.

Each polype does not appear to produce more than two or three eggs; in *Plumatella* frequently only one. In *P. Allmani* they, Pl. III. fig. 5 *f*, are considerably depressed, of an oval form, sometimes very long with the sides almost parallel; they are very large, being sometimes almost as wide as the diameter of the cell, within which they are placed lengthwise; the margins are reticulated, yellow, pellucid, thin, and sharp, forming a well-defined rim about the central portion, which is opake and black; the covering is smooth, tough, and membranous. In *Fredericella* the egg is broader and more regularly oval, of a brownish colour with the margin narrow, plain and of a paler hue. The egg, Pl. IV. fig. 7 *e*, of *Paludicella*, if egg it be, differs considerably from the above. It is of an irregular oval shape, about half as wide as the cell, colourless and pellucid; the surface is marked with a few indistinct, irregular, nucleated cells; one larger and much more conspicuous than the rest, with a distinct round nucleus in the centre, is always to be seen on one side. The circumference of the egg exhibits a double margin indicating an enveloping shield.

The great size of the egg forbids the possibility of its escape without the destruction of the polype*. In *Plumatella*, the

* The polype of the marine species must also perish on the escape of the gemmule. On examining some specimens of *Bowerbankia* in August, almost every cell was found to contain a large, round, opake, bright yellow corpuscle. These corpuscles were for the most part in the lower portion of the cells; some however were halfway up, and others not far from the top: those lowest down were the smallest, and as they approached the top they increased in size until their diameter was nearly equal to that of the cell. As long as the corpuscle remained near the lower extremity of the cell, the polype was alive and active; but was invariably dead when it had advanced far upwards. At first the corpuscle does not appear to have any envelope, but as it increases in size a distinct margin makes its appearance, which afterwards becoming wider and perfectly transparent, the corpuscle can be seen rotating within by the aid of the long cilia that clothe its surface. While watching one in this state under the microscope, I observed it gradually elongate itself and pass with a slow gliding motion to the top of the cell; then forcing its way through the previously closed orifice, and passing into the surrounding fluid, commenced to rotate with extraordinary velocity: in an instant after this its enveloping membrane was torn open and cast aside, and the little being, a broadly ovate gemmule, dashed at once beyond the field of view. It afterwards kept moving about in various

ova on maturity become attached to that side of the cell which is connected to the substance sustaining the polypidom. And here they remain fixed, indicating the track of the various branches of the Bryoozon long after its decay and disappearance in autumn. The free branches however must scatter their eggs. Most likely in *Fredericella,* too, they are dispersed, and borne away by the currents on the destruction of the polypidom, which is very freely branched; and in no instance have I seen its eggs left adhering to the surface of its attachment.

Having now gone through the details of the anatomy and development of the freshwater *Bryozoa* as far as I have been able to study them during a very short but laborious investigation of the subject, it is quite evident that these animals are as highly organized as the marine Ascidian polypes. *Plumatella* and *Fredericella* certainly show some interesting deviations from that type; but in *Paludicella* we perceive an almost complete resemblance to it; proving the close affinity that exists, and the propriety of uniting the whole into one group. The approximation of this genus to the marine forms is evinced not only by the muscular system, but likewise by the digestive apparatus; and by the bright, pellucid, horny character of the external polypidom. It is also equally evident that the organization of this group is very much above that of the typical *Radiata.* This Professor Allman has already clearly demonstrated; and yet perhaps we ought to hesitate before removing the *Bryozoa* into the subkingdom *Mollusca* as proposed by this naturalist.

The immediate relationship of these animals to the *Ascidiæ* is too obvious to be called in question,—a relationship which has long been acknowledged, though the homology of the parts does not appear to be correctly understood; at least it will bear another interpretation, which I am inclined to look upon as the true one. Dr. Farre observes in his paper, that "in *Tunicata* the tentacles are reduced to mere rudiments at the entrance of 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."

This view of the relationship of the parts has with some modifications been generally followed by subsequent writers. In all the Ascidians however, there is a well-defined œsophagus,

directions and evinced great activity, cilia densely clothing it from end to end. The cell after the escape of the gemmule continued gaping; and the polype, which before was indistinctly visible, had now quite disappeared, nothing but slight traces of the retractor muscles remaining.

which in *Clavelina* is frequently of great length. Why then should the entrance to it be considered to correspond to the cardia in *Bryozoa*? These as well as the *Ascidiæ* have a well-marked stomach with cardiac and pyloric orifices; in both, too, there is a distinct œsophagus; then should not the orifice leading to it be assumed to be the mouth, or analogous to the mouth in both? In the polype a series of respiratory tentacles, in the *Ascidiæ* the branchial sac, surrounds this mouth; should not these then be considered homologous? The affirmative of this would appear to be the natural inference in the first instance. But we are referred to the tentacular filaments at the entrance of the respiratory sac as the true representatives of the tentacles of the polype. With the view to ascertain how far this is correct, I examined with much care *Ascidia sordida* and *Molgula arenosa*, and found that these tentacular filaments are not anatomically connected with the branchial sac, but are developments from the tunic. The sac terminates a little way below these filaments, and they fringe the inner circumference of the belt of sphincter muscles which guard the respiratory orifice. These tentacular filaments, then, originating in the tunic, cannot possibly be the homologue of the tentacles of the polype, as these undoubtedly belong to the alimentary canal; but are in fact a new development in connexion with the sphincter of the tunic, and share its function. The tentacles then of the polype and the branchial sac of the Ascidian would appear to be homologous;—unless indeed the tentacles of the one have died out, and the branchial sac of the other is altogether a new development, which is not by any means likely.

In confirmation that the former is the fact, we have only to look at the growing bud of the polype, which so closely resembles an Ascidian, particularly when young, that it might at first sight be taken to be one. The tentacles at this time, all lying parallel to each other within the membranous sheath, have quite the appearance of a branchial sac; and when we take in connexion with it the alimentary canal, the resemblance is almost complete. Indeed, all that is wanting to turn the polype into an Ascidian, so far as the alimentary and respiratary organs are concerned, is the union of the tentacles by a vascular membrane. And we have already seen that such an union has commenced in *Fredericella*, *Plumatella* and *Alcyonella*. We have seen that in all these genera the tentacles are united at the base by a delicate membrane; and in the former this membrane is so extensive as to suggest the idea of a rudimentary form of the branchial sac of the *Tunicata*.

Taking this view of the homology of the parts, the longitudinal laminæ in the interior of the branchial sac of the *Ascidiæ* will represent the tentacles of the *Bryozoa*; and the membrane at the base of the tentacles being external corresponds exactly in position to the vascular membrane of the *Ascidiæ,* which is also external to the laminæ. The position of the nervous ganglion in the two forms might at first sight appear to favour the contrary opinion; but on closer inquiry it is evident that the ganglion of the *Bryozoa* is not homologous with that of the *Ascidiæ*: in the former it is a cerebral ganglion resting on the œsophagus immediately behind the mouth; in the latter, if it has relationship to any of the nervous centres of the *Mollusca,* it is apparently analogous to the branchial ganglion of the *Lamellibranchiata*; but its position in the mantle is anomalous.

We thus see how very intimate is the connexion between the *Bryozoa* and the *Ascidiæ*; and as the latter are generally supposed to be as closely connected with the *Lamellibranchiata,* no great distance would appear to divide them from the former. They are not, however, so closely related as might be supposed. At first sight an Ascidian undoubtedly seems very closely to approximate to a bivalve shell; but this similarity on careful investigation would appear to be more that of analogy than homology—a mere resemblance rather than a true relationship. The branchial sac of the Ascidian is frequently assumed to be the same organ as the gill-plates of the *Lamellibranchiata* somewhat modified;—in function there is no difference; but anatomically they are distinct. The former is a development from the alimentary canal; the latter, according to Professor Owen, "are essentially internal folds of the pallial membrane." The breathing organs then of these animals are not homologous. To turn therefore an Ascidian into a Lamellibranchiate mollusk, a new branchial organ must be developed. The vascular system, too, if not anatomically different in the Ascidian, is in a remarkable manner functionally so. In this the heart is at once systemic and pulmonic. And it is worthy of remark, that thus, on the first appearance of the vascular apparatus in this type of animals, it should shadow forth the peculiarities of both the molluscan and the piscine heart; and this, too, in connexion with a pharyngeal gill. The test or outer sac, and the inner sac or tunic of the *Tunicata* are not related to each other in the same manner as the shell and mantle of the mollusk. In this the shell is extra-vascular, and is secreted by the mantle; in the former the test is vascular, and its growth is therefore not dependent on that of the inner sac or tunic. The reproductive system of the *Lamellibranchiata* is likewise very different from that of the *Tunicata.* In these it is formed on the type of the *Radiata*; another and very striking proof of the relationship that exists between the former and the *Bryozoa.* These and other points of difference led Professor Milne-Edwards, in his valuable memoir on the 'Ascidiens Composées,' to propose the separation of the *Tunicata* from the *Mollusca*, and the formation of them into a distinct group to be placed between the bivalves and the polypes.

We then cannot find a passage from the *Bryozoa* through the *Ascidiæ* into the *Lamellibranchiata*. There are however two distinct branches of the Ascidian polypes,—one with the tentacles arranged in a circle about the mouth,—the other having them supported on two lateral oral arms. The former of these branches passes into the Ascidian,—the latter I shall endeavour to show is connected with the *Brachiopoda*.

This connexion is at once suggested by the resemblance that exists between the oral arms of *Plumatella* and *Alcyonella* and the characteristic brachial organs in the *Brachiopoda*, particularly of those in *Lingula*. In both the *Brachiopoda* and the *Bryozoa*, the arms rise from the sides of the mouth in the same manner, the bases of the arms being confluent; and the tentacles or cirrhi forming a continuous series. In both the arms are hollow, and the tentacles and cirrhi are tough and non-contractile; and in both they are prehensile organs after the same fashion. The digestive organs of both are very similar; and the whole of the *Brachiopoda* are fixed, and so are the *Bryozoa*, with but one exception.

But what is still more remarkable, the muscular systems of both are arranged much in the same manner, particularly as respects *Terebratula* and *Paludicella* with most of its marine congeners. In *Terebratula*, as the animal is fixed within the shell, of course there can be nothing resembling the polype retractors; but the shell muscles of *Terebratula* will be found to work exactly on the same principle as those provided to draw in the margins of the cell-orifice in *Paludicella* and *Bowerbankia*, and called by Dr. Farre opercular muscles.

There are four sets of muscles in connexion with the shell in *Terebratula chilensis* as dissected by Owen, two from each valve; and they all pass diagonally downwards, and with one exception go to be inserted in the pedicle; so that when they contract the valves will be closed. These muscles then have in fact their origin in the pedicle as stated by Owen, and acting from thence upon the moveable points of their insertions, operate precisely in the same way as the tube-retractors of the polypes last mentioned do on the lips of the orifice. The action is the same in both; and were the cell-walls of *Bowerbankia*, for instance, calcified and divided longitudinally into two portions or valves, they would be made to close just as the valves do in *Terebratula*. The set of muscles alluded to as not passing into the pedicle comes from the perforate valve, and inclining downwards is attached by the other end to the base of the imperforate valve, binding the parts of the hinge-joint together—a substitute in fact for a ligament. In some species this set assumes in part the function of an adductor muscle.

We have then evidently some reason for supposing that the *Brachiopoda* as well as the *Ascidiæ* are related to the *Bryozoa*; and it is in this way that these latter are connected with the *Lamellibranchiata*. After a careful examination of the *Brachiopoda*, it is impossible to doubt the connexion that exists between the two great divisions of the testaceous *Acephala*. Indeed this is evident, whether we look to the digestive organs, the vascular system, or to the reproductive apparatus. It is in these animals, too, that the respiratory organ is first found in connexion with the mantle,—in *Terebratula* quite rudimentary, in *Lingula* to some extent specialized. On comparing *Anomia* with *Orbicula*, this relationship is best seen. In both the mantle is completely separated, and in both it is connected with the ovary; the large oral palpi of the one form the homologue of the branchial organs of the other; and we see this relationship in the deficiency of pedal organ in *Anomia*, and in the extensive union that still subsists between its breathing apparatus and the mantle: the perforation of the under-valve of both is also remarkable; but not more so than that the great muscle of both should be divided,—part forming the adductor, part the adhesive disc.

We have now endeavoured to trace the affinities of both branches of *Bryozoa*; one appears to pass at once into the *Ascidiæ*, which, how closely soever related analogically to the *Lamellibranchiata*, are nevertheless removed far from them by the nature of their vascular, respiratory and reproductive systems. In the *Mollusca* the heart is always systemic, and the gill is universally an appendage to the mantle. In the *Ascidiæ* the heart is as much pulmonic as systemic, and the breathing apparatus is a development from the alimentary canal—is in fact pharyngeal. In these respects the Ascidian deviates from the Molluscan type and approximates to that of the lower *Vertebrata*,—the fishes, in which the heart is pulmonic and the breathing organ pharyngeal. The reality of this relationship is revealed by the anatomy of the Lancelet so ably described by Professor John Goodsir, who has pointed out the resemblance of its respiratory system to that of the *Tunicata*. Indeed the branchial sac and vascular apparatus of this curious fish almost completely resemble those organs in the Ascidian.

The other branch of the *Bryozoa*, comprising those with oral arms, passes into the *Brachiopoda*; or at least this is rendered more than probable by the resemblance of the brachial organs of the latter to the arms of the former, and by the similarity of the muscular arrangement. Thus the *Bryozoa* become related to the *Lamellibranchiata,* which are apparentlyclosely related to the *Brachiopoda.* We may conclude then, if we have arrived at a right understanding of the affinities of these animals, that both the *Mollusca* and *Vertebrata* are connected with the *Bryozoa.* It would be well therefore to pause before including the *Bryozoa* in the *Mollusca,* and consider the propriety of uniting the former with the *Tunicata,* and perhaps with some of the higher forms of *Rotifera,* into a group to be placed at the head of the *Radiata.*

Descriptions of new Species.

Plumatella punctata. Pl. V. figs. 6 & 7, and Pl. III. fig. 1.

Polypidom adhering throughout, coriaceous, pellucid, of a pale watery green colour, irregularly but not much branched, seldom extending more than half an inch; branches composed of a series of large, conical cells tapering upwards towards the aperture, sometimes considerably and rather suddenly dilated at the base; resembling in form some of the Ascidians; the upper portion of the cell almost colourless and freckled with minute opake white spots, most crowded towards the orifice. Tentacles white, not more than sixty in number; membrane at their origin rather wide, scalloped, the points of the scallop extending for some distance up the back of the tentacles in the form of broadish laminæ arched outwards. Œsophagus and stomach appearing through the transparent walls of the cell of a pale yellow colour. Egg perfectly black, large, broad and oval.

Upwards of a dozen specimens of this fine species occurred in Bromley Lough, adhering to the underside of stones; it was likewise taken in Crag Lough. None of the individuals much exceeded in size that represented in the figure, nor did they vary in any remarkable manner either in form or colour. It is not, however, without hesitation that I have ventured to characterize this as a new species, as Professor Allman informs me that it may perhaps turn out to be *P. repens*; but that form is stated to be large and of luxuriant growth, and to have the polypidom tubular with the cells dilated at the orifice—characters which do not at all agree with *P. punctata.* Indeed it can scarcely be considered a true *Plumatella.*

P. Allmani. Pl. V. figs. 3 & 4, and Pl. III. figs. 2 & 3.

Polypidom attached to the underside of stones, adhering throughout, membranous, opake, yellowish brown, slightly branched, extending in patches sometimes three or four inches wide, the patches being made up of several polypidoms; the branches composed apparently of a series of tubular cells, tapering to their origin, and attached for more than half their length; the enlarged extremity, being free and bending upwards, inclines a little to one side, and is occasionally bifid, forming two cells; an obtuse ridge or keel extends the entire length of the cell, increasing imperceptibly in thickness upwards; orifice somewhat constricted, the walls immediately below being pellucid, and suddenly dilating become abruptly opake and thickly covered for some distance downwards with agglutinated sand. Tentacles forty-two in number, slightly tinged with yellow, the colour best seen when they are formed into a compact bundle; membrane at their base distinct, scalloped, the points being prolonged a little up the tentacles. Egg black, long, oval; sides nearly parallel; margins pellucid, yellow, sharp, broad and reticulated.

This species was procured rather abundantly in Bromley Lough, and does not appear to vary much. At first sight large patches of it have the appearance of being formed of a single polypidom; but on close examination are found to be composed of many, and rarely to number more than six or eight cells in each. The commencement of each polypidom has the black envelope of the originating egg adherent.

Two or three specimens of a more branched form of carinated *Plumatella* were taken in Bromley Lough, which may probably prove a distinct species; more individuals however are necessary before it can be characterized.

Paludicella procumbens. Pl. V. figs. 1 & 2, and Pl. IV.

Polypidom membranous, subhorny, pellucid, smooth and glossy, of a brownish horn-colour, much and irregularly branched, forming large patches on the underside of stones, for the most part adhering, with rather numerous, short, free, almost simple branches; the branches composed of a single series of narrow cells arranged longitudinally, contracting towards the base and widening upwards; aperture lateral, near to the upper extremity of the cell, forming a rather long and somewhat constricted tube inclining upwards; margin entire, surmounted by a widish, delicate, hyaline, membranous cup. Tentacles sixteen in number, arranged in a complete circle, and when spread out forming a very exact inverted cone.

This, the second species of the genus, resembles very closely *P. articulata* of Allman, but that form appears to have about twenty-six tentacles, and is likewise more densely and luxuriantly branched; the cells, too, are larger and of a different colour.

The *P. procumbens* occurred in both Bromley and Crag Loughs, but most abundantly in the latter, where it spreads over the under surface of stones in patches of 5 or 6 inches diameter.

EXPLANATION OF PLATES II., III., IV. AND V.

PLATE II.

Fig. 1. Upper portion of *Fredericella sultana* seen as a transparent object very much magnified: *a*, tentacular disc; *b*, tentacles; *c'*, membrane at base of ditto; *c*, flounced margin of ditto; *d*, mouth; *e*, oral valve; *f*, œsophagus; *g*, projecting lips of cardiac orifice; *h*, stomach; *i*, intestine; *j*, anus; *k*, nervous ganglion giving off nerves; *l*, tentacular sheath doubled upon itself; *m*, strong radiating muscles for preventing complete inversion of ditto; *n*, delicate radiating muscles in connexion with the orifice of cell; *o*, outer wall of cell; *p*, inner wall or tunic; *q*, inverted lips of orifice; *r*, the point where the same unite to the tentacular sheath, immediately below which is the sphincter for closing the cell.

Fig. 2. Retracted polype of *Plumatella Allmani* seen by transmitted light and much magnified: *a*, bundle of tentacles enveloped in membranous sheath; *a'*, tentacular disc; *b*, œsophagus; *c*, projecting lips of cardiac opening; *d*, stomach; *e*, intestine; *f*, anus; *g g*, muscles for retracting the polype; *h*, large radiating muscles for preventing complete inversion of tentacular sheath; *i*, delicate radiating muscles in connexion with the orifice of cell; *j*, outer wall of cell; *k*, inner membrane or tunic; *l*, inverted margin or lips of orifice; *m*, tentacular sheath; *n*, sphincter contraction of ditto; *o*, bud in second stage of development; *p*, tentacular sheath of ditto forming; *q*, retractor muscles in an incipient state.

Fig. 3. Upper portion of the cell of *Plumatella Allmani* much enlarged: *a*, bud in first stage of development attached to the inner surface of lining membrane of cell.

Fig. 4. Cell with exserted polype of *Fredericella sultana* much enlarged and seen as a transparent object: *a*, tentacular disc; *b*, oral valve; *c*, œsophagus; *d*, stomach; *e*, intestine; *f*, the two bundles of polype retractors; *g*, two fibres of same for rotating tentacular disc; *h*, egg in connexion with ovary, attaching it to lower end of stomach and wall of cell; *h'*, appendage to the lower end of stomach, probably generative; *i i*, outer wall of cell; *j j*, lining membrane or tunic; *k*, bud in third stage of development; *l*, tentacles of ditto as they at first appear; *m*, stomach of do.; *n*, retractor muscles of ditto; *o*, nucleated cell—the incipient egg in connexion with the ovary.

Fig. 5. Bud in third stage of development more highly magnified: *a*, tentacular disc; *b*, œsophagus; *c*, stomach; *d*, intestine; *e*, incipient egg in enlarged portion of ovary; *f*, wall of cell.

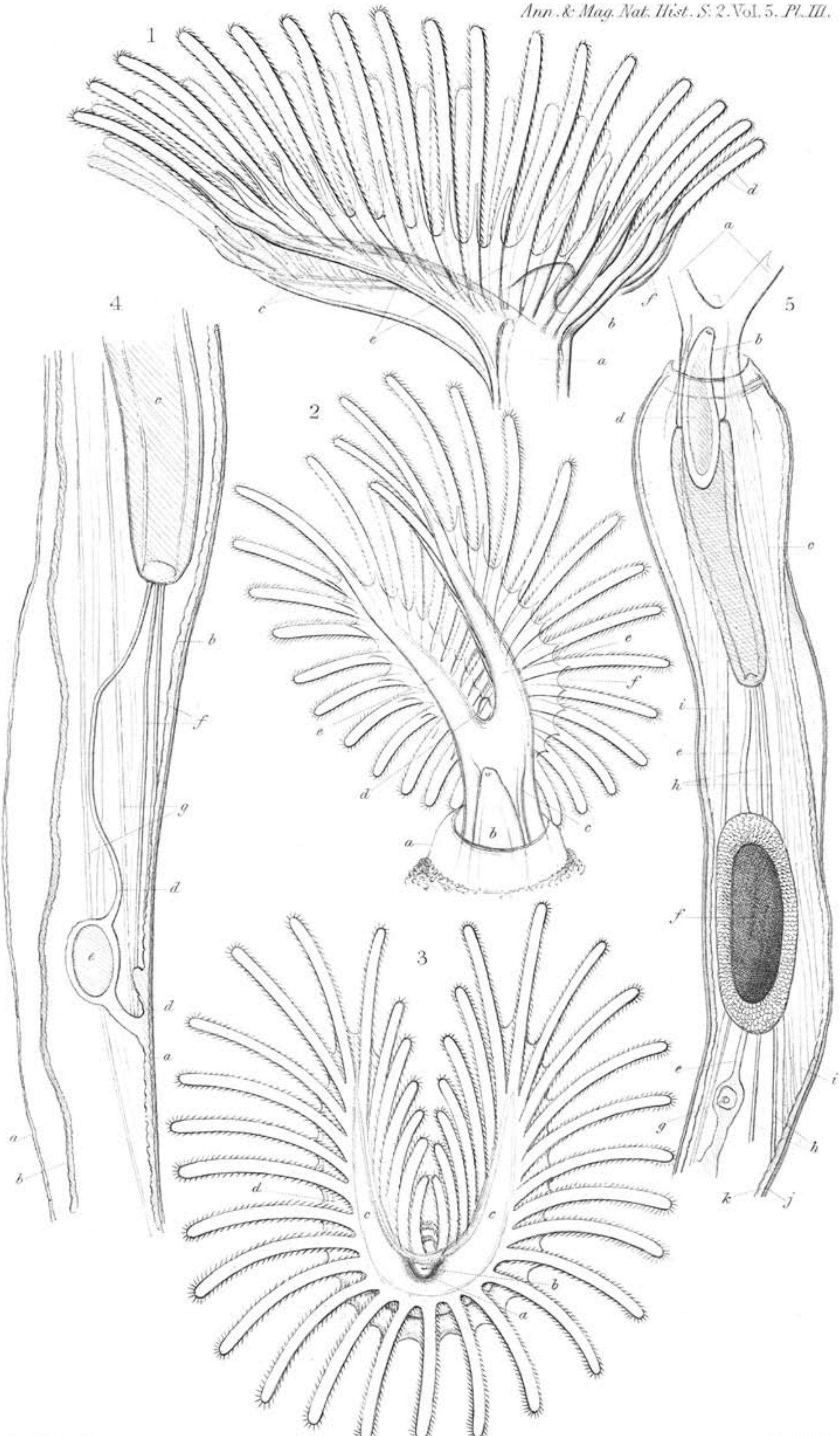
Fig. 6. Egg and ovary much enlarged of *Fredericella sultana*: *a*, egg imbedded in ovary; *b*, wall of cell to which lower end, *c*, of ovary is attached; *c'*, upper portion of ovary leading to stomach.

PLATE III.

Fig. 1. Side view of exserted tentacular apparatus much enlarged of *Plumatella punctata*: *a*, œsophagus; *b*, oral valve; *c*, tentacular or oral arms; *d*, tentacles; *e*, membrane at base of ditto; *f*, laminæ at back of ditto.

Fig. 2. Enlarged view of under side of tentacular apparatus of *Plumatella Allmani*: *a*, margin of orifice of cell; *b*, intestine; *c*, œsophagus; *d*, oral valve; *e e*, oral arms; *f*, membrane at base of tentacles.

Fig. 3. Enlarged view of the upper side of tentacular apparatus of *Pluma-*



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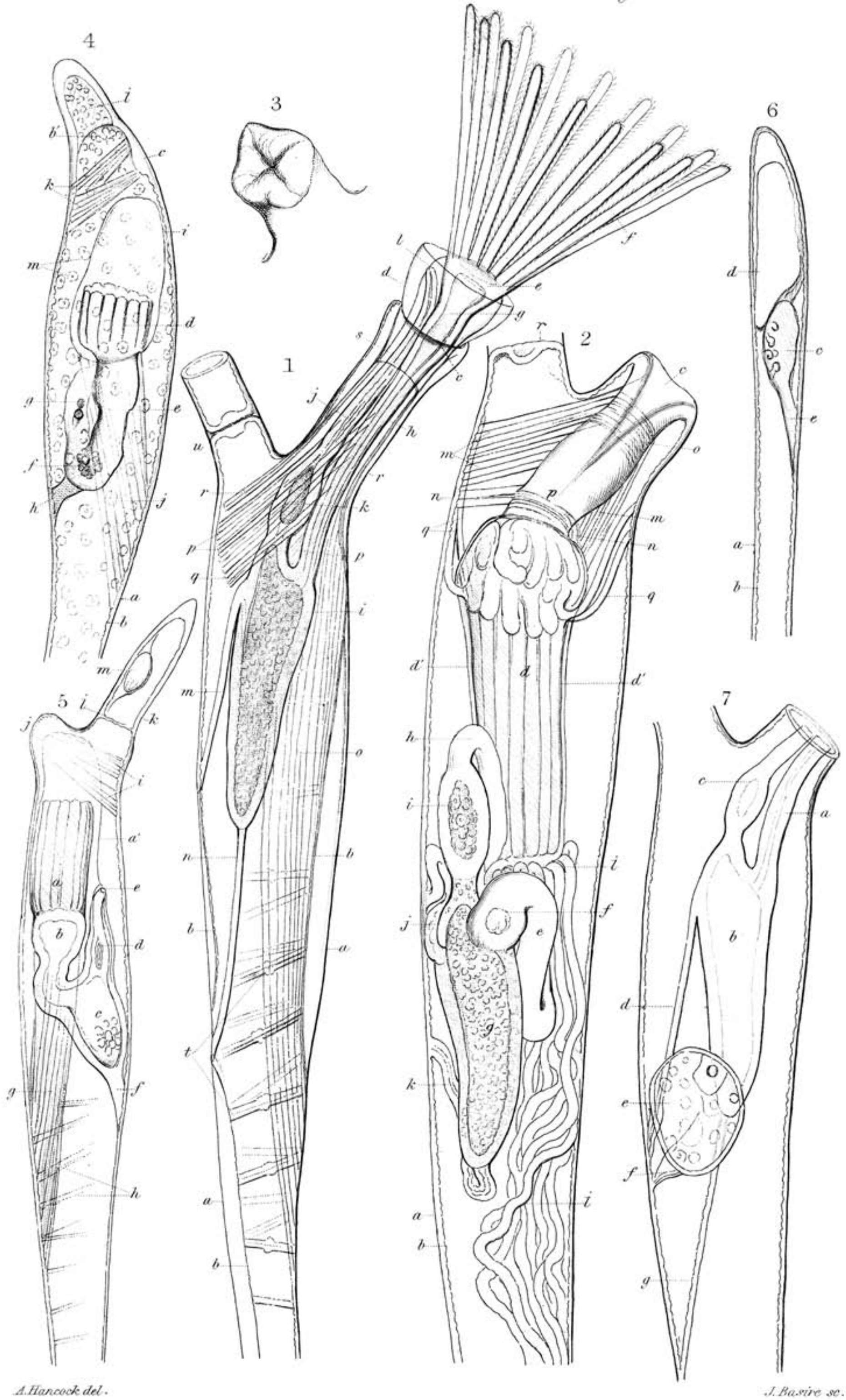

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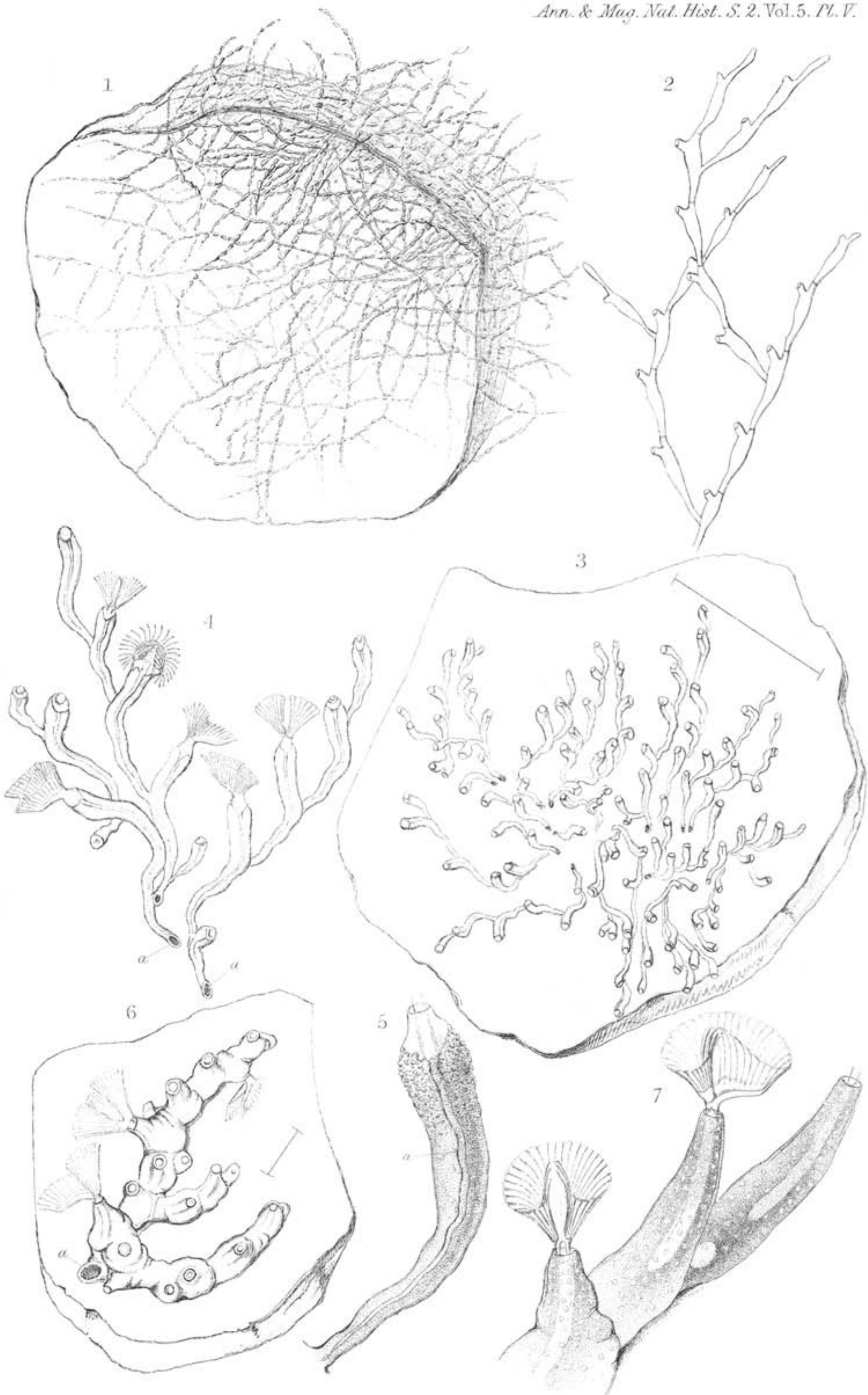

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J. Basire sc.

tella Allmani: *a*, mouth; *b*, oral valve; *c c*, oral arms; *d*, membrane at base of tentacles.

Fig. 4. Much-enlarged view of the reproductive organs of *Fredericella sultana*: *a a*, outer wall of cell; *b b*, lining membrane or tunic; *c*, lower portion of stomach; *d d*, ovary; *e*, egg imbedded in same; *f*, two filaments attached to the lower end of stomach, probably connected with the reproductive system; *g*, retractor muscles.

Fig. 5. Enlarged view of a cell of *Plumatella Allmani* exhibiting reproductive organs: *a*, base of oral arms; *b*, œsophagus; *c*, stomach; *d*, intestine; *e e'*, ovary; *f*, egg nearly mature, still attached to ditto; *g*, an egg just forming likewise attached to ovary; *h h*, two filaments attached to the stomach, probably connected with the reproductive system; *i i*, the two bundles of retractor muscles; *j*, outer wall of cell; *k*, lining membrane or tunic.

Plate IV.

Fig. 1. Enlarged view of a cell of *Paludicella procumbens* seen as a transparent object, the polype being exserted: *a a*, outer wall of cell; *b b b*, lining membrane or tunic; *c*, tubular orifice; *d*, membranous cup surmounting ditto; *e*, tentacular disc; *f*, tentacles; *g*, pharyngeal swelling; *h*, œsophagus; *i*, stomach; *j*, intestine; *k*, enlargement at commencement of ditto; *l*, anus; *m*, supposed ovary; *n*, filament attached to the lower extremity of stomach, probably connected with the reproductive system; *o*, polype retractor muscles; *p p*, inferior tube-retractors; *q*, two fibres of superior tube-retractors; *r r*, muscles to prevent the complete inversion of tentacular sheath; *s*, tentacular sheath doubled upon itself; *t*, parietal muscles; *u*, end-walls of two cells abutting against each other.

Fig. 2. Enlarged view of a single cell of *P. procumbens* with polype retracted: *a*, outer wall of cell; *b*, lining membrane of ditto; *c*, retracted tubular orifice; *d*, tentacles; *d' d'*, tentacular sheath; *e*, œsophagus; *f*, cardiac orifice; *g*, stomach; *h*, intestine; *i*, enlarged portion of ditto; *j*, supposed ovary doubled upon itself; *k*, filament attached to lower end of stomach, probably connected with reproductive system; *l l*, polype retractor muscles; *m m*, inferior tube-retractors; *nn*, superior tube-retractors; *o*, sphincter muscles for closing orifice; *p*, do. do.; *q q*, muscles to prevent complete inversion of tentacular sheath; *r*, end-wall of cell formed by the tunic exhibiting enlargement in the centre.

Fig. 3. End of retracted tube of *P. procumbens* exhibiting the manner in which it folds in

Fig. 4. Termination of a branch of *P. procumbens* comprising two cells in different stages of development: *a*, outer wall of cell in fourth stage of development; *b*, lining membrane of ditto; *b'*, blind termination of do. do.; *c*, place of future orifice; *d*, tentacles of polype in state of development; *e*, œsophagus; *f*, stomach; *g*, intestine; *h*, lower reproductive organ; *i*, tentacular sheath; *j*, polype retractor muscles; *k*, tube-retractors; *l*, new cell in first or earliest stage of development, exhibiting lining membrane and external wall; *m*, nucleated cells in lining membrane.

Fig. 5. Two terminal cells of *P. procumbens* containing buds in different stages of development: *a*, tentacles of bud far advanced or in fifth stage of development; *a'*, tentacular sheath; *b*, œsophagus; *c*, stomach; *d*, intestine; *e*, anus; *f*, lower reproductive organ; *g*, polype-retractors; *h*, parietal muscles; *i*, tube-retractors; *j*, tube just forming; *k*, outer wall of last-formed cell exhibiting bud in second stage of development; *l*, lining membrane of ditto; *m*, bud as it appears at first.

Fig. 6. Terminal cell exhibiting bud in third stage of development: *a*, outer wall of cell; *b*, lining membrane; *c*, bud; *d*, tentacular sheath; *e*, polype-retractors just making their appearance.

Fig. 7. Enlarged view of a portion of the polype of *P. procumbens* exhibiting reproductive system: *a*, œsophagus; *b*, stomach; *c*, intestine; *d*, supposed ovary with the egg, *e*, attached; *f*, membranous envelope of the egg; *g*, lower filament supposed to be connected with the reproductive system.

PLATE V.

Fig. 1. Polypidom of *Paludicella procumbens* slightly enlarged.

Fig. 2. A portion of ditto much enlarged, exhibiting two or three series of cells.

Fig. 3. A patch of *Plumatella Allmani* magnified two times, comprising several polypidoms.

Fig. 4. Two or three polypidoms of ditto more highly magnified, exhibiting the polypes exserted and the envelope of the originating egg *a a*.

Fig. 5. A single cell of same still more highly magnified: *a*, keel or ridge on the upper surface of cell.

Fig. 6. *Plumatella punctata* five or six times magnified, exhibiting polypes exserted: *a*, envelope of originating egg.

Fig. 7. Three cells of ditto more highly magnified and more produced than usual, with the polypes exserted.

XIX.—*Contributions to the Botany of South America.* By JOHN MIERS, Esq., F.R.S., F.L.S.

[Continued from p. 35.]

BROWALLIA.

THE affinity of *Browallia* with *Salpiglossis* is sufficiently evident, but in many respects it approaches very closely to *Petunia*. In the tabular arrangement suggested on a former occasion (*huj. op*. iii. p. 172), *Browallia* was associated with the *Salpiglossideæ*, on account of the apparent æstivation of its corolla, combined with its other characters. I regret very much, that since my attention has been directed to this investigation, I have had no opportunity of examining a flower in its living state, as by this means only could its precise mode of præfloration be ascertained: it is certainly not imbricative as in *Franciscea*, but is either replicative or reciprocative, as in *Petunia* or *Salpiglossis*; judging from its appearance after being pressed and dried, it seems to be rather that of the last-named genus. The following generic features have been derived wholly from an examination of dried specimens:—

BROWALLIA, Linn. (char. reform.).—*Calyx* tubulosus, subcylindricus, 10-nervis, 5-dentatus, dentibus inæqualibus, 3-nerviis,