XIII. *Observations on Polyzoa. Suborder Phylactolæmata.* By Alpheus Hyatt.

With nine Plates.

[Communicated October 10,* 1864.]

Introduction.

The investigations recorded in the following pages are the results of observations made on the American species of the Phylactolæmata; with the intention of elucidating the structure of the genera, and of presenting the laws of their structural combination as fully as this can be accomplished within the limits of the present communication.

For this purpose synoptical tables have been given, exhibiting the anatomy of the different divisions, as far as our knowledge of the adult animals would permit.

Had such a plan been possible at the present time, the synopsis would have embraced only the anatomy of the most complicated species of each generic series; and other tables, similarly constructed, illustrating every genus, would have been prefixed, one individual of each species being selected for analysis. But the small number of species now known in each genus not affording material enough for perfecting this system, the tables include only general statements of the characters of each genus, and these are arranged in a linear series in order to show clearly their serial relations. I venture, however, to assert, that, notwithstanding these defects, the results obtained by this mode of procedure are more exact, than if the usual methods of describing the anatomy had been followed.

The advantages of thus analyzing the anatomical features of any natural division are at once apparent. Their organization, as a whole, is rendered plain; and the reader is enabled to trace, throughout the structure of the group, not only the changes of any organ by itself, but even of

*During the proof reading I have embodied in the original text many new facts discovered since the 10th of Oct., 1864, and the communication, therefore, may be considered as covering a period extending from that date to the day of publication.

the different systems of organs, from their lowest to their highest states.

The laws, also, according to which the changes, or differences in the parts, take place, are better illustrated by such a tabular view, than by any other method.

The manner commonly pursued of describing the minute differences between species, or genera, and of simply generalizing with regard to their anatomical peculiarities, is very unsatisfactory. It does not afford the means for comparing the anatomical composition of the parts of the individual in each species, or genus, which is necessary to a complete understanding of the whole, and the differences are sought for and described, to the neglect of the agreements, that are either passed by, or only casually noticed in the descriptions of the larger divisions. Such errors are avoided by the use of analytical tables, which, besides the advantages before described, set forth the similarities as prominently, as the differences. We thus never lose sight of the initial points of the structure, while the differences, or changes, from time to time appearing, stand out even more vividly against the common background of similarities.

It is far from my intention to underrate the labors of naturalists who devote themselves to the discovery and publication of new forms; their labors are essential to the progress of science. The ordinary mode, however, of prosecuting these investigations is, perhaps, too disconnected, species being habitually regarded in the light of isolated creations, rather, than as allied to others by the larger number of their essential characters. This engenders a habit of always looking for differences, and overlooking agreements, which the study of series of species, or even of series of individuals would correct.

The facts published in these "Observations" have been verified by my own experience, with the single exception of the spermatozoa. These I have not yet seen, my observations having been made, for three successive seasons, principally during the fall and winter months.

The questions involved in the body of the paper, and the difficulties to be overcome in obtaining living European specimens have obliged me to quote extensively from the works of foreign naturalists. References, however, are always made to the original publications, and the statements used have been, in all cases, sifted of facts that did not correspond with my own researches upon closely allied American species.

The nomenclature of Professor Allman's exhaustive "Monograph of the Fresh-water Polyzoa" has been adopted throughout, with the exception of a few alterations, which become necessary, partly in consequence of some ideas of my own, with regard to the composition of the organs, differing from those of Prof. Allman, and, partly, because I here adopt a new view of the relations of the anterior and posterior poles of the body, originated by my friend Edward S. Morse.* In an article published in these Proceedings he homologizes the parts of the animal in the various classes of the Mollusca, and arrives at the conclusion, as surprising, as it is truthful, that the attached end of a Polyzoön is in reality the anterior, and that the peduncular end of a Brachiopod is the homologue of this, and, also, anterior.

It therefore becomes necessary to alter the commonly received nomenclature, and to denominate the attached end of a Polyzoön the anterior; the free end the posterior; the anal side the dorsal; and the opposite, or so called hæmal side, the ventral.

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*A Classification of Mollusca based on the principle of Cephalization. Proc. of Essex Inst., Vol. IV, No. VI, p. 162.

Note. I am indebted to Dr. Joseph Leidy, of Philadelphia, for identifying my specimens of Fredericella regina with his species, for tracings of all the species described by him, and for other valuable information. I desire, also, to return thanks to Professor H. J. Clark, of Harvard College, Professor A. E. Verrill, of Yale College, Professor Alfred Mayer, of Penn. University, Professor Theodore Gill, of the Smithsonian Institution, Mr. Elliott Smith and Mr. S. I. Smith, of Norway, Maine; to all of whom I am under obligations for important assistance.

My thanks are also due to the Officers of the Smithsonian Institution, of Washington, and the Peabody Institute, of Baltimore, for the use of books which I could not have otherwise obtained.

It is but just that I should also express the feelings of gratitude with which I cherish the memory of my father, Mr. Alpheus Hyatt, of Baltimore, whose long continued generosity, while living, enabled me not only to accomplish this undertaking, but to plan, and prosecute others of a similar kind.

Mr. Edward S. Morse perfected the drawings with the skill of an

The unquestioning manner with which I take up these views may excite some surprise, but they are founded upon facts which calmed all the doubts I at first entertained, and satisfied me entirely of their correctness. Mr. Morse's paper, entitled "*A Classification of the Mollusca based on the principle of Cephalization*," fully illustrates the homologies, as well, also, as the general plan of that subkingdom.

Mr. Morse has, also, done me the honor of quoting from my manuscript the term *Saccata* as a new name for the Mollusca. Since it has been so auspiciously introduced to science, and, as such a definitive term seems to be needed to give uniformity and completeness to the nomenclature of the four plans, I shall make no further excuse for its employment in the future.

Bibliography and Classification.

There is no bibliography of the Phylactolæmata, or in fact of the Fresh-water Polyzoa taken together, as far as our own country is concerned, but, in Europe, they have, from the time of Trembley,* their discoverer, attracted much attention, and the list of works, that may be consulted with profit, is extensive. The principal among these are the writings of Dumortier and Van Beneden, Professor All-

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accomplished draughtsman, and with all the interest of a zoölogist and personal friend. I am indebted to him both for this, and for many other favors that have rendered it possible for me to publish at an early date. In fact, my only regret, in connection with this article, is, that a gentleman of such acknowledged ability, whose time is important to science, should not be able to devote it to his own original investigations.

The lenses employed were made especially for the purpose by Robert B. Tolles, of Canastota, N. Y. The one half inch objective having an angle of 175° and one fifth of an inch working distance was especially well suited for the examination of living animals.

Mr. J. F. Richardson, of Portland, executed the engraving of the plates with the same skill he has shown in other scientific works, and with more than usual care.

The wood cuts are very large for a black ground, and, being printed directly from the wood, required all the skill and patience of Mr. Holland to produce accurate impressions.

*Mémoire pour servir à l'histoire d'un genre des polypes d'eau douce. 1744.

man, and Mr. Albany Hancock.* These experienced naturalists surveyed the whole field, and, armed with powerful modern microscopes, they completely disclosed the anatomy and physiology, making nearly all preceding explorations interesting only as matters of history.

Dr. Leidy is the sole authority upon this subject in America.† His observations have given us all the information we at present possess of our native species, besides adding two new and singularly interesting genera, Pectinatella and Urnatella, to the systematic catalogue. Of these two, Pectinatella alone belongs to the Phylactolæmata.

Nothing of a general nature having been published in this country, it may, perhaps, be well, before proceeding with the structural analysis of the Phylactolæmata, to give a sketch of the classification and a description of the different forms of this suborder.

The Polyzoa, for a long time confounded with the Radiata, were first definitely separated by Thompson in 1830, and called by him Polyzoa, thus taking precedence of Bryozoa, the name afterwards given them by Ehrenberg in 1831.‡

In 1834, De Blainville, although still continuing to associate them with the Radiata, set off the genera Cristatella, Plumatella and Alcyonella as a subclass, styling them "Polypiaires douteux."||

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*Dumortier & Van Beneden. Hist. Nat. d. Polypes composés d'eau douce. Nouv. Mem. de l'Acad. Roy. de Bruxelles. Vol. 16. 1843.

Van Beneden, Recherches sur les Bryozoaires. Mem. de l'Acad. Roy. de Belgique. Vol. 21. 1848.

Dumortier & Van Beneden. Hist. Nat. des polypes com. d'eau douce. Mem. de l'Acad. Roy. de Bruxelles, comp. au tom. 16. 1848.

Albany Hancock. On the Anatomy of the Fresh-water Bryozoa, with descriptions of new species. Ann. and Magazine of Nat. Hist. Vol. 5. 1850.

Prof. Allman. Monograph of the Fresh-water Polyzoa. Ray Society, 1856.

†Dr. Joseph Leidy. Proc. Philadelphia Acad. of Nat. Sciences, Vols. 5, 7, and 10.

‡Busk. On the priority of the term Polyzoa. Ann. and Mag. Nat. Hist. 2d Ser. Vol. 10, p. 352. 1852.

||De Blainville. Man. d'Actinologie et de Zoöphytologie. p. 489. Paris. 1834—37.

In 1837, Gervais divided the Polyzoa into two subclasses, "Polypiaires hypocrepia," and "Polypiaires infundibulati." The first included the genera with lateral arms, and the second those with round lophophores, among which he placed Fredericella.*

In 1848, Fredericella was restored to its proper division by Dumortier and Van Beneden, but they committed the mistake of uniting it with Paludicella, a genus with a truly orbicular lophophore, and devoid of an epistome.† These authors, also, recognized the Hypocrepian division, as limited by Gervais, separating Fredericella and Paludicella as a distinct group.

Professor Allman in 1856 instituted the order Phylactolæmata, basing it upon the epistome, which is present in all the genera.‡

He divides the order into two suborders; Lophopea and Pedicellinea, the former including all the Hypocrepian forms, and the latter the marine genus Pedicellina. Although differing from Professor Allman in my estimation of the relations of Pedicellina, I have retained his name for the Fresh-water genera, from Fredericella to Cristatella inclusive.

In the Suborder Lophopea, he has two grand groups, or families, founded upon the characteristics of the cœnœcium; one the Cristatellidæ, for the genus Cristatella with its locomotive cœnœcium; and the other the Plumatellidæ, embracing all the remaining genera, that have rooted cœnœcia.

There is a partial coincidence between Professor Allman's classification and the one I advocate. He makes of his Plumatellidæ two groups; one equivalent to my first family including Fredericella, because of the obsolete arms, and another including precisely the same genera as my second family. Thus the classifications virtually agree in regard to the number of the principal groups, although not with regard to their relative values.

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*Gervais. Recherches sur les Polypes d'eau douce. Annales des Sciences Naturelles, 2d Ser. Vol. 7, p. 77.

†Dumortier & Van Beneden. Memoirs de l'Acad. Roy. de Belgique. Vol. 21, p. 5. 1848.

‡Allman. Fresh-water Polyzoa. p. 10.

According to this view of their relations, the PHYLACTOLÆMATA comprise three families, or subgroups. First; the *Fredericellidæ*, founded upon the great differences between the lophophore and nervous system of Fredericella, and the members of the other families. Second; the *Plumatellidæ*, which differ from the Fredericellidæ in the lophophore and nervous system, and from the Cristatellidæ in their cœnœcial characters. Third; the *Cristatellidæ*, whose cœnœcia and mode of development separate them widely from both the preceding.

The following is a scheme of this classification, enumerating the families and genera by name, and the number of species at present known in America, Europe, India and Australia.

Suborder.	Families.	Genera.	No. of species in America.	" " " Europe.	" " " India.	" " " Australia.	
PHYLACTOLÆMATA.	FREDERICELLIDÆ.	Fredericella.	3	1			
	PLUMATELLIDÆ.	Plumatella.*	5	13		1†	
		Lophopus.	1‡	1			
		Pectinatella.	1		1‖		
	CRISTATELLIDÆ.	Cristatella.	2	1			
			12	16	1	1	30

*Plumatella includes Alcyonella, which is only a variation of the ordinary form of the species.

†A species of Plumatella mentioned, but not named or described, from Melbourne, and the vicinity of Richmond. D. Oyly H. Alpin. Ann. and Mag. Nat. Hist. 3d Ser. Vol. 6, p. 454. 1860.

‡A species mentioned by Dr. Leidy. Proc, Phil. Acad. Nat. Sciences, Vol. 10, p. 190.

‖A statoblast, found near Bombay and described by Mr. J. H. Carter in the Ann. and Mag. of Nat. Hist. Vol. 3, p. 341, pl. 8, f. 8-15, 1859, supposed by him to belong to Lophopus crystallinus. It, however, undoubtedly belongs to a new species of Pectinatella, and I therefore propose for this new species, which is remarkable for its spines, furnished with many lateral hooks, growing only from the ends of the statoblast, the name of *Pectinatella Carteri*.

FREDERICELLA.

These are plant-like animals with graceful dendritic forms, common in our brooks and ponds (Pl. 7). They cling, immovably fastened by their ectocyst, to the lower surfaces of submerged stones, or floating boards; and thrive best in the darkest places, often carpeting the dismal recesses, under the loosened bark of dead branches, with their lovely, campanulate corollas.

Nothing can exceed the exquisite beauty of these small "phytozoöns"; their symmetrical outlines, the alertness of the motions of the polypides, and the surprising complexity of the internal structure of their transparent bodies richly repay the labors of the microscopist.

Cœnœcium. This part of the colony, formed by the tubular dark brown trunk and branches, is made up of lines of little hollow twigs, or cells, each separate cell encasing a single polypide, and opening into the preceding cell, or parent Polyzoön, at the lower end. Thence the cells are generally attached for some distance to the surface, although frequently the entire branch is free, the lowest cell alone being attached. The extremities of the cells bend upwards, and are always free, but vary exceedingly in length. The color is due to the ectocyst, which is a thin gelatinous excretion, soft, and transparent when first deposited, but acquiring with age a dark brown hue and parchment like consistency (Pl. 7, figs. 4, 5, D). This excretion is the product of the cœnœcial endocyst, or true body wall of the branches and polypides (Pl. 7, figs. 4, 5, 6, E). The endocyst is continuous throughout the general system of branches or cœnœcium, and the latter may, therefore, be regarded as a common tubular cavity, more or less cut up into cells. Some scattered, partial divisions, made by ring-like folds of the endocyst, open in the centre, are found in each colony, but these are not constant, and occur only at rare intervals in the branches.*

Polypide. The free portions of the cells are capped by translucent tubes crowned with thread like tentacles radiating from the periphery of the Lophophore, or floor of the

*Similar to those of Plumatella. Pl. 8, fig. 6.

crown. This is perforated in the centre by the round mouth, overshadowed by the tongue like Epistome (Pl. 7, fig. 5, I′, I″), which is an obtuse, upward fold of the lophophore, opening below into the neural chamber, or cavity. This cavity contains the orbicular nerve-mass suspended immediately under the epistomic opening (Pl. 7, fig. 5, S).

The surface of the tentacles, the oral side of the epistome, the lophophore and the interior of the throat in the vicinity of the mouth are covered by cilia (Pl. 7, figs. 4, H, 5, H″). Constantly vibrating towards the centre of the crown, these cilia create a vortex in the water, at the apex of which lies the mouth, always open and ready to engulph the microscopic plants, or Infusoriæ, that may be caught by the encircling current, and swept into this liquid trap (Pl. 7, fig. 5, I″).

The polypides not unfrequently form a sort of cage, by interlacing the extremities of their tentacles, and imprison the more active of the Infusoriæ, who would otherwise readily escape. Thus inclosed, however, their strength is expended in fruitless efforts to break through the tentacular bars, until finally exhausted and overcome, by the power of the miniature maelstrom, they are whirled unresistingly downward into the funnel shaped throat.

The tentacles are used not only, as above described, to catch the prey, but for a multitude of other offices. They are each capable of independent motion, and may be twisted or turned in any direction; bending inwards, they take up and discard objectionable matter, or push down into the stomach and clear the œsophagus of food too small to be acted upon by the parietal muscles. They are also employed offensively in striking an intrusive neighbor, and their tactile power, sensitive to the slightest unusual vibration in the water, warns the polypide of the approach of danger.

Between the lophophore and the cœnœcium, the internal organization is plainly seen, the pellucid wall of the tube offering no obstacle to the eye of the observer.

The alimentary canal hangs from the lophophore, occupying the centre of the polypide, and floating freely in the rapidly moving blood. The yellowish œsophagus, the stomach barred with brown, and the brownish intestine compose a deeply colored axis relieving and vivifying the shadowy outlines of the tube and tentacular crest (Pl. 7, fig. 5, K, K′, K″).

All these delicately proportioned members are balanced upon a fold of the endocyst, called the Invaginated Fold (Pl. 7, fig. 5, B), which is retained within the cœnœcial cell by the Retentor muscles (Pl. 7, fig. 4, 5, N, N′). These together with numerous other sets of small muscles will be described hereafter. At present it is only necessary to call attention to the Sphincter (Pl. 7, fig. 6, L), a broad, contractile band surrounding the invaginated fold, and the large retractors (Pl. 7, fig. 4, fig. 8, M, M′, M″), which are in two sets, one on each side of the alimentary canal. They arise apparently from two common bases, but each large trunk subdivides above into many bundles, which may be distinguished from each other according to the location of their attachments and divided into three branches.

The fibres of the first branch, the Gastric Retractor, are distributed to the stomach; those of the second, the Lophophoric Retractor, to the œsophagus and oral region; those of the third, the Brachial Retractor, to the bases of the arms, and to the endocyst along the line of the Brachial Collar. The crest is swayed by these muscles in every direction; or, when alarmed, the polypide may withdraw by their aid into the larger cœnœcial tube below, very much as the finger of a glove may be inverted within the empty palm. This is so quickly done, at times, as to baffle observation, and the fully expanded polypide, with every tentacle stretched to its full length vanishes instantaneously within the cœnœcium. Often, however, the invagination is more slowly performed, and the motions can then be easily followed.

The polypidal endocyst is first turned inwards, folding upon itself, and prolonging the permanently invaginated fold below. The tentacles, arriving at the edge of the cœnœcial orifice, are pressed into a compact bundle by the action of their own muscles, and, together with the lophophore, are dragged into the cell by the continued invagination of the endocyst until they are wholly inclosed and at rest within the sheath formed for them by the inverted walls of the tube. The sphincter muscle then closes the cœnœcial orifice above, and the process of invagination is completed.

The polypide in its exserted state is buoyed up and sustained by the pressure of the fluids within. Consequently when invaginated it displaces an equal bulk of these in the closed cœnœcium, and their reaction, aided by the contraction of the muscular endocyst, is sufficient to evaginate the whole.

The evagination begins with the relaxation of the sphincter, which permits the ends of the tentacles to protrude. These daintily feel about for the cause of the alarm, and, if they fail to detect the proximity of an enemy, the whole fascicle is cautiously pushed out, and the sentient threads suddenly and confidently unfolded.

The polyzoön reasons from the sense of touch inherent in its tentacles, and cannot be induced to expose itself above the cœnœcium until thoroughly satisfied, by these sensitive feelers, that no danger is to be apprehended. In fact, these plantlike creatures, singly mere pouches with a stomach hanging in the midst, exhibit greater nervous activity and "animality," than we find among the more highly organized Ascidia, or shell-covered Brachiopoda.

PLUMATELLA.

The species of this genus abound near the shores of our ponds, close to the surface, and are generally in company with Fredericella (Pl. 8). They may be found attached to the under sides of flat stones, or floating boards, but do not usually seek the narrow, dark recesses in which Fredericella often occurs. Better fitted to endure the sun's rays, they may, occasionally, be seen in positions exposed to their full influence. I have been so fortunate as to collect specimens of P. Arethusa which were growing from the ends of the long water grasses; their tiny branches, and living, crystalline flowers glittering in the light, and swaying to and fro in the open current without protection from the heat, even at midday.

The cœnœcium is dendritic as in Fredericella, but the growth is generally more luxuriant, extending over larger surfaces, and the cœnœcial cells are wider in proportion to their length. The polypide, also, is capable of more extended protrusion, and its motions, therefore, are less restrained. The arms, previously indicated in the lophophore of Fredericella, are fully developed, and stretch out on the dorsal side just above the anus, giving a crescentic, or horse-shoe shaped aspect to the disk, which is retained throughout the succeeding genera.

The ectocyst may be either transparent or brown in the same species, and the polypides may be widely separated, as in Fredericella, or be closely aggregated, the branches and cells adhering together by means of their gelatinous ectocysts.

LOPHOPUS.

Lophopus introduces us to a new class of characters. The ectocyst, in place of being a thin enveloping sheet, is a thick deposit of clear jelly in which the cœnœcium is buried. The branches are lobiform, and the cells even less widely separated, or differentiated, than in the aggregated varieties of Plumatella.

Prof. Allman describes Lophopus crystallinus as attached to the stems of Lemna, and other fresh water plants, but avoiding exposure to bright sunlight.

These positions must necessarily, however, be less shaded than those occupied by the majority of the Plumatellæ.

PECTINATELLA.

The reproductive and vital energies of the group reach their climax in the voluptuous beauty and endless multiplication of the cœnœcia in Pectinatella (Pls. 9, 10, 11, 12).

The cells of the separate polypides are wholly merged in the lobiform branches, and the gelatinous ectocyst, often several inches thick, is gathered underneath the cœnœcia (Pl. 9, fig. 5, D). It affords a common base for all the colonies, and is no longer, as in the preceding genera, confined to one cœnœcium.

The tropical aspect and luxuriant growth of the clinging masses, frequently several feet in diameter, investing the summits of submerged stumps, and the branches of waterlogged timber, are unequalled among the fresh-water, or even among the marine Saccata of our climate.

The communities, assembled in countless profusion upon the gelatinous ectocyst, are crowded together and being compressed become irregularly hexagonal in their outlines. The polypides upon the lobiform branches, adorn the borders of these hexagonal patterns with a dense, glistening fringe, speckled with the scarlet coloring of their oral regions; and the bare cœnœcial trunk (Pl. 9, figs. 5, 6, 7, A′) in the centre shine with a deep, opaline lustre, completing the rich, coralline effect of the fringed outlines.

The protrusion of the polypides is not limited by the invaginated fold, as in the preceding genera, but they roll out nearly the full length of their evaginable endocyst, and resemble columns supported by a simple ovolo and fillet (Pls. 10, 12). The fillet corresponds to the invaginated fold of the preceding genera, and the ovolo-like bend in the endocyst is produced by the contraction of the anterior retentor muscles.

In July and August specimens of Pectinatella magnifica are very abundant in shallows and in the depths of Pennissewasse pond, but as the fall advances, those in the shallows die, and in October they can live only upon the logs in deep, cool water, or in shaded situations. These autumnal specimens are old, and being unable to withstand the direct rays of the sun, disappear from all exposed positions, where they grow with impunity as strong and healthy adults earlier in the season. I have found them fifteen or twenty feet below the surface, showing a marked departure in this respect from the preceding genera, whose species seldom occur below two, or three feet, and are almost invariably near the shore line.

CRISTATELLA.

The Cristatellæ are by far the most highly organized, not only of the Phylactolæmata but of all the Polyzoa (Pls. 13, 14).

The cœnœcia are neither dendritic, as in Fredericella and the Plumatellæ, or lobate, as in Lophopus and Pectinatella, but naked, depressed sacks, capable of determinate motion; their interior divided by walls of reticulating muscular fibres into numerous radiating cells and tubes. The latter, however, do not meet internally, but leave a vacant space in the centre of the cœnœcial trunk unoccupied either by the polypides, or the muscular walls (Pl. 13, figs. 2, 3, A′).

The polypides extend to the full length of their evaginable endocyst, and are destitute of an invaginated fold, not even possessing a fillet around the upper edge of the cœnœcial orifice as in Pectinatella (Pl. 14, fig. 1). They are disposed in rows upon the borders, inclosing the clear, bare central spaces with an edging not unlike the polypidal fringes of Pectinatella (Pl. 13, fig. 1).

The ectocyst loses the fixed character it still possessed in Pectinatella, and is only a transient, gelatinous excretion, thrown off in great abundance from the common base of the colony (Pl. 13, fig. 3, D).

The communities are not invariably gathered upon a common ectocyst, as in Pectinatella, but are sometimes single, as in Lophopus.

There is, however, a very curious, and remarkable similarity of one species with Pectinatella.

The cœnœcia of C. ophidioidea herd together within confined boundaries from a few inches to a foot or more in diameter, covering such favorite resorts with a glairy coating accumulated upon the surface by the moving bases of the numerous colonies. The aspect of one of these settlements, supported upon this common ectocyst, is analogous to that of a mass of Pectinatellæ; especially to the old age, or degradational period of the life of a mass of the latter; where a large number of colonies still cling to a thin sheet of gelatine left from the decay of the greater part of the ectocyst.

This similarity may be explained by the fissiparous multiplication of the cœnœcia in both genera and the slow progression of Cristatella. The colonies of the last can never wander far from their place of origin, unless floated off by some accident, and, continually multiplying, they soon create a dense population in a comparatively small space.

The distribution of Cristatella is similar to that of Pectinatella, they being generally found together.

Reproduction.

The Phylactolæmata have two modes of reproduction, one by buds, and the other by eggs. The former occurs in two ways; by statoblasts, either fixed or free, and by regular buds, which grow out from the side of each polypide. The first are the founders of new colonies. The last merely increase the number of individuals in each established community. The colonies are, however, sometimes multiplied by other processes, which cannot be classified under either of the above heads. In large specimens of Plumatella Arethusa the polypides on the old trunk die first and the remnants of the cœnœcia are gradually swept away, leaving the branches as so many independent colonies (Pl. 8, fig. 1). This, also, is not uncommon with Plumatella diffusa, and is, probably, peculiar to all the species of this genus that distribute their branches over a large surface.

I have directed, perhaps, more attention to the old age than to any other period of the growth of the individual, and among the many curious and novel facts, which this comparatively untravelled path of investigation has led me to, there are few more interesting than the above.

Specimens of Fredericella may be often observed attached near the ends of their branches by the soft ectocysts of their younger polypides, the ragged end of the branch floating freely above. These may sometimes have been torn by accident from the parent colony, but in the majority of cases they owe their liberation to the decay of the original stock. In Pectinatella and Cristatella the march of extinction is, also, from within outwards. But, in consequence of the greater width and the common occupation of the cœnœcium by the polypides, the decay of those in the interior does not effect the vitality of the trunk, and their living cœnœcia carry both the quick and the dead (Pl. 9, fig. 11).

Thus death, which is an active agent in multiplying the number of independant colonies in Fredericella and Plumatella, is, probably in Lophopus, and certainly in Pectinatella and Cristatella, of no avail; the constrictive power of the endocyst being its functional substitute in the three last named genera. Although the polypides of the Phylactolæmata never display any marks of fissiparity, the cœnœcia are multiplied by division. I have seen the lobiform branches of old colonies of Pectinatella divided from the cœnœcial trunk by constrictions, which, gradually deepening, finally separated them from the latter. The form, the thickness of the ectocyst, and the vast number of cœnœcia upon every mass, indicate, that this selfmultiplicative mode of propagation is of frequent occurrence among the adults.

Prof. Allman has observed similar phenomena in Cristatella and Lophopus, showing it to be common to all the genera having the thickened gelatinous ectocyst. It appears probable, that this method of multiplying the colonies would also take place in Fredericella and the Plumatellæ, if it were not for the toughness of the ectocyst. The partial divisions continually occuring in the branches of these genera and, apparently, restrained only by the stiffness of the ectocyst from becoming effective and severing the cœnœcia, wherever they occur, into separate parts, are the homologues of the permanent septa between the cells of Paludicella and of the lateral partitions in the marine Polyzoa. This homology was suggested to me in observing the readiness with which the lobes of Pectinatella were cut off; the constrictions occuring irregularly, sometimes isolating a whole branch, sometimes only a few cells. If the ectocyst was pergameneous in this genus the constrictions would either not take place at all, or form scattered partitions, as in Fredericella and Plumatella. Thus the same function that produces a constant anatomical character in Paludicella, Fredericella, and Plumatella, would seem to be the effective cause of the selfmultiplication of the cœnœcia in Lophopus, Pectinatella and Cristatella.

Prof. Allman divides the mode of reproduction by buds into two, "non sexual reproduction by gemmæ, which at once proceed to the full term of their destined development," and "by statoblasts or gemmæ in which the developmental activity remains for a period latent."*

The statoblasts bud from the funiculus, a cord like pro-

*Fresh-water Polyzoa. p. 41.

longation of the outer membranes of the stomach, connecting the lower end of that organ with the bottom of the cell in the vicinity of the bases of the retractors.

The researches of Mr. Hancock, upon the early development of the statoblast, which he supposed, in common with other observers of that time, to be a true ovum, and those of Prof. Allman, give an almost complete history of their growth.* The former found them in Plumatella and Fredericella, in the interior of the funiculus, as large nucleated cells; and the latter, apparently begining his investigation at a later period, as a mass of smaller cells, which must have resulted from the division of the primary cell of Mr. Hancock.

They arise within bead like swellings of the funiculus, and, enlarging slowly, push out to the surface of the chord, and upwards towards the stomach, until finally they hang upon the exterior, arranged alternately on either side, the youngest being at the lower end (Pl. 8, fig. 2, W).

According to Prof. Allman the contents increase in bulk by the formation of new cells, and are enveloped in a cellular membrane (Fig. 1, a) with an outer gelatinous envelope (Pl. 8, fig. 2, W''''). Between these, two other membranes are secreted, one of which constitutes the horny sheath, and the other the annular ring of the statoblast (Pl. 8, figs. 7, 8, 9, W', W''). This sheath and the annulus gradually assume a distinct cellular structure, and a horny consistency; the former at the same time acquiring a deep brown color, and the latter a brilliant golden hue.

The contents of the statoblast are often contracted, and, while in this condition, during the earlier stages of development before the horny casing becomes too opaque, the membranes may be analyzed by the aid of the microscope.

The interior cells are large and colorless. They are surrounded by a thin, homogeneous membrane, which, when the cellular contents are reduced by contraction, seems to be drawn out into numerous, minute, conical projections at the points where it is attached externally to the overlying membrane (Fig. 1, b). I was unable on account

*Albany Hancock. Ann. Nat. Hist. Vol. 5. p. 190.

of the opacity of the sheaths of the specimens of Fredericella regina, upon which my investigations were principally made, to determine with absolute precision, whether these conical projections were tubes, or partly solid muscular bands connecting the investing membrane with the overlying layer (Fig 1, a).

The cellular contents do not project into the interior of the cones, as they might be expected to do, if the latter were simply hollow continuations of the investing membrane. This fact may be considered as favoring the opinion, that they are partly solid, and, perhaps, muscular, connective bands, or else there must be another membrane interior to the one described, which, also, invests the cellular contents and prevents the cells from flowing into and filling up the conical projections. The overlying layer (Fig. 1, a) is exceedingly thick, and acts, in all respects, like a muscular membrane. It is unconnected with the horny sheath, and either lies closely against the latter, or is separated from it; and may be smooth and of equal thickness throughout, or corrugated and of unequal thickness, as in fig. 1, according to its state of expansion, or contraction.

The horny sheath is composed of flattened, hexagonal cells, the whole surface garnished internally with a thin coating of short, horny, brown colored setæ (Fig. 1, W′). This sheath is so exceedingly tough and hard that it is difficult to pierce it with the point of a needle.

The annuli of the statoblasts of Plumatella, and of the other genera in which they are found, are made up of more prominent and larger hexagonal cells than those of the horny sheath.

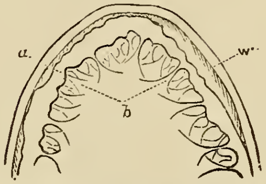

FIG. 1. Section of the end of a statoblast of FREDERICELLA REGINA; *b*, conical projections on the surface of the cellular contents; *a*, thick, muscular membrane; *w*', horny sheath.

In Fredericella the annulus is not developed, but in all the other genera it is, and in Pectinatella and Cristatella spines are superadded.

These spines apparently arise from the annulus in Pectinatella, as described by Dr. Leidy, but they may be traced by a close examination of this part, by transmitted light, to their junction with the body of the statoblast. From the edges of the statoblast they pass through the centre of the annulus, coming out on the border of the seam, that divides the upper and lower sides of the annulus.

Prof. Allman describes the statoblasts of Cristatella as surrounded by a ciliated envelope before the spines begin to be developed, and remarks, that these impinge upon this membranous envelope, which gives way before them and disappears. I have been unable to detect any similar ciliated membrane in Plumatella or Pectinatella, and, in this respect, Cristatella probably differs from all the other Phylactolæmata. The gelatinous matrix of the statoblast of Pectinatella does not reach its full growth before the spines are produced, but appears to be carried up on their sides as they progress outwards. When the spines are fully developed, the reentrant spaces in the envelope between them become filled out, and they are buried in the gelatine, like those of Cristatella when they first begin to protrude from the horny sheath.

The gelatine is absent from the full grown statoblasts of Fredericella and Plumatella, which are found naked in the cœnœcial cells, whereas those of Pectinatella and Cristatella are enveloped by it until after the death of the colony; losing it only by decay. In the two first this covering is not essential, and it is absorbed before the bud is floated out of the cœnœcium, while in the two last it is needed in order to protect the parent from laceration by the pointed hooklets of the spines, and it is, therefore, retained until lost by the exposure of the bud to external influences.

Before the spines of Pectinatella appear, and often, even before the horny casing shows the deeper shades of the brownish coloring that afterwards distinguishes it, the statoblasts are detached from the funiculus. They lie loose in the cœnœcial cavity from this time until the death and decay of the polypides destroy the upper parts of the cells. Through the openings thus made, being lighter than water, they are readily floated off and pass the winter unprotected by any other covering than their cellular casings, although remaining near the surface, and consequently, in the higher latitudes, imbedded in the ice for several months.

Growth begins at the approach of spring and the edges of the sheath are split apart by the increasing bulk of the polyzoön, which protrudes between them. The opacity of the sheath has hitherto prevented microscopists from ascertaining the early history of the development of the polypide, and we are obliged to be content with such observations as can be made during the later periods of its life, when it is partly exposed.

The organs, when the little animal first makes itself visible, are well advanced in growth and the polypide is already capable of retraction and expansion. For a time it floats freely in the water, wafted about by the cilia, which clothe the whole external surface, and increases in size until the sheaths of the statoblast can no longer contain it; then, in some appropriate locality, the gelatinous ectocyst adheres to the surface, the cilia are absorbed, and the polypide enters upon a new phase of life as the founder of a community.

The sides of the sheath and the annulus, although separated from each other, frequently cling to the bud, and may occasionally be found adhering to its sides even after the colony has attained its full size.

Besides these floating buds, which might be called free statoblasts, there are others, originating in a similar manner, but from the attached or lowermost sides of the cells instead of the funiculus. These remain permanently fixed by their external investment to the endocyst, and, on this account, I have called them fixed statoblasts. They have been described in Plumatella emarginata and Alcyonella (Plumatella) Benedeni by Prof. Allman, and by Dr. Leidy in Plumatella nitida.*

It may be well to remark here, that the location of the free statoblast in Fredericella is different from what it is in all other genera. After dropping in the usual manner from the funiculus they become soldered to the sides of the parent cells, and being of the same size, are indistinguishable from the true, fixed statoblasts.

The fixed statoblasts found in Plumatella are much

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*Dr. Leidy. Proc. Philadelphia Acad. Nat. Sciences, Vol. 5. p. 321.

larger than the free forms, have no annulus, and in many species the walls of the cells immediately under them become so compact and hard, that they cannot be removed from the surface of the wood or stone to which the cell is attached without considerable exertion.

Certain so called exceptional forms of buds, also, previously noticed by Prof. Allman in Alcyonella fungosa and Lophopus crystallinus, are very abundant in Cristatella, on the interior of the basal membrane* (Pl. 13, figs. 2, 3, 8, 9, 10, 11, 12, X). They are at first small oval bodies near the border, jutting out from the endocyst of the tubes leading to the second or third line of polypides. Their composition is similar to that of the statoblast. They have a thick external membrane and granular contents, but are devoid of a gelatinous envelope, and, also, have a large vacant spot in the interior which is continually varying its shape and position. Simultaneously with them, and continuous with their outer envelope, a long ridge springs up from the endocyst and the outer membrane of the bud, which, becoming membranous, splitting into two portions, and connecting with the upper side of the cœnœcium, eventually incloses them in a tube (Pl. 13, figs. 8, 10, 11, Q̃). This ridge sometimes passes directly over the centre of the bud, and sometimes to one side, but is almost always present. It occasionally retains the cord like embryonic character, and freeing itself from the endocyst, except at the extremities, forms a pseudo-funiculus, suspending the bud in the cœnœcial cavity. The thick external membrane becomes in course of time differentiated from the walls or ridges, and acquires the horny consistency of the casing on the free statoblast, but is never so opaque, or deeply colored. As the outer membrane stiffens no change seems to be made in the granular contents, but the more convex face of the envelope sinks, forming an elliptical depression, and the greater number of the buds become free (Pl. 13, fig. 12, W′). Prof. Allman found them to be hollow, and described this elliptical depression as an aperture. I was, however, unable to substantiate either of these con-

*Allman. Op. cit. p. 40.

clusions in Cristatella. The rupture of the sheath and the consequent escape of its contents is not an uncommon occurrence among the fixed statoblasts of Plumatella; and this seems to have been the cause of the emptiness of the specimens described by Prof. Allman. From their mode of development, and the place they occupy in the cœnœcium, it is probable that they are the same as the fixed statoblasts of Plumatella. They differ, however, from the fixed statoblasts in being unattached to the endocyst when fully grown, but this not being an invariable character, and the elliptical depression, which is nothing more than the accidental sinking in of one side of the sheath, being quite common, even among the free statoblasts of Plumatella, I see no reason for considering them exceptional forms.

At an early stage of growth, while still floating freely in its native element, the statoblastic polypide begins to multiply by the process of budding. An internal swelling of the endocyst, on the lower side, in the vicinity of the bases of the anterior retentor muscles, first shows the position of the coming polypide. This elongates into a little hollow sack with a thickened rim (Pl. 7, fig. 5, Y), upon the upper edge of which, in the Hypocrepian Polyzoa, a slight notch is formed by the duplication and pushing out of its sides into two loops joined along the centre (Pl. 13, fig. 4, Y). A series of minute folds of the membrane on the upper sides of the loops are the incipient tentacles, and, as they enlarge, the intervening membrane is drawn up with them like a thick web; but this, however, eventually recedes externally and becomes the calyx. The loops growing outward augment their longitudinal diameter at the expense of the transverse, and the inner sides of each, approximating and at last coalescing, make up the lophophore and arms. Preceding the beginning of the tentacles, a transverse constriction of the body of the little sack draws the line between the œsophagus, and the stomach; and the subsequent deepening of this constriction divides off the internal cavity, establishing the cardiac and pyloric valves. The muscles, which become well differentiated at a very early period, are divisible into three pairs: one pair attached to the rim, the Brachial Retractors; one to the region of the œsophagus, the Œsophagal Retractors; and one to the region of the stomach, the Gastric Retractors. They are active from the first, and appear to drag the polypide inwards, stretching the endocyst of the parent, which is joined to the loops, into a tube. This tube is the future evaginable endocyst of the polypide; and, as the various organs are developing, it is everted little by little, becoming gradually capable of the adult evagination.

The tentacles of Cristatella ophidioidea are not fully grown, nor the arms divaricated, until long after the evagination of the polypide is completed (Pl. 13, fig. 3, Y′). At this period the tentacles of the external rows near the mouth are the longest, decreasing regularly to the mere tubercles on the ends of the arms, and the internal tentacles are not separated from each other, exhibiting only two closely appressed lines of tubercles all of about equal length. The division of the arms begins internally, and its progress outwards may be followed by the gradually increasing length of these interior rows, which retain their tubercular character until this division commences (Pl. 9, fig. 14).

The mode of reproduction by true ova, although detected by Dumortier and Van Beneden, was first fully described by Prof. Allman. They are produced from the gemma dot, a bud-like mass on the upper side of the endocyst in the neighborhood of the orifice, which, during the fall, when not filled with ova, becomes opaque and granular.*

The testicle, first described by Dumortier and Van Beneden, arises from the funiculus, resembling in its mode of formation, according to Prof. Allman, a true bud. The

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*Prof. Allman thus describes the earlier periods of the development of the ovum. Monograph Fresh-water Polyzoa p. 33.

"*Development of the Ovum.*—I have succeded in tracing the development of the ovum through most of its stages in Alcyonella fungosa.

In this polyzoön the mature ovum consists of a granular vitellus, surrounded by a very evident vitellary membrane, on whose internal surface the contents appear frequently to be aggregated in a coarse granular layer. It presents a large germinal vesicle, and a very distinct germinal spot. After a time the germinal vesicle and the germinal spot disappear, and the vitellus undergoes segmentation, and after the mulberry-like condition thus induced has in its turn vanished, we find the contents of the egg have assumed the form of a roundish or oval body, richly ciliated on its surface, and provided with a large cennuclei of the cells are of large size and in due time are converted into spermatozoa. These have been observed swimming freely in the perigastric cavity into which the full grown ova are, also, discharged from the ovary.

After the segmentation of the vitellus, the egg appears as a hollow oval body clothed externally with cilia, and it is at this period that most observers have seen and described its peculiarities.

Mr. Albany Hancock, although confounding it with a statoblast which he supposed to be an egg, speaks of one, an undoubted ovum, which, he observed forcing its way through the closed orifice of the cell, rending and destroying the parent polypide in its course.*

I have, also, seen them during this stage in Plumatella

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tral cavity, which as yet does not open externally. When liberated from the outer membrane of the ovum, which still confines it, it swims actively through the surrounding water by the aid of the cilia with which it is invested.

As development proceeds, we find the ciliated embryo while still confined within the coverings of the egg, presenting in some part of its surface an opening, which leads into the central cavity; and through this opening an unciliated, hernia-like sac is capable of being protruded by a process of evagination. The unciliated protrusible portion would seem to have been derived by a separation from the walls of the central cavity, and appears therefore to originate by a process of unlining, a true chorization.

Towards the opening, which leads from without into the central cavity, the chorization is incomplete, the membrane as it separates being here still held to the walls of the cavity by irregular transverse bands; these bands check the entire evagination of the membrane, but after a time they disappear, and then the unlining and evagination are perfect. In the interior of the protrusible portion, and before the disappearance of the transverse bands, a polypide is developed." The further development of this polypide, as described by Prof. Allman, does not differ materially from those produced from the regular buds of the adult cells.

The same authority thus describes the testicle of Alcyonella (Plumatella) fungosa on page 32 of the work above quoted.

"The testicle is composed of a mass of spherical cells, each of which contains within it numerous secondary cells, "vesicles of evolution." The visible contents of the vesicles of evolution consist, at first, of nothing more than a well-defined spherical nucleus, and this is subsequently transformed into a spermatozoal filament, which finally escapes by the rupture of the containing cells. The spermatozoal filaments, in this genus, are simple vibrioid bodies without any terminal enlargement."

*Hancock. Op. cit. p. 186, note.

Arethusa, squirming in the perigastric cavity, and tossing the stomach of the polypide about, as if it had been a plaything. They certainly, in this species, evinced sufficient power to open a passage through the thin membrane of the polypide, although such did not seem to be their object at the time.

No orifices for the expulsion of the ova have been as yet positively demonstrated. Meyen chronicles the escape of the eggs of Alcyonella (Plumatella) stagnorum from an opening in the vicinity of the anus.* But this is, probably, erroneous, since, as observed by Mr. Hancock, "the great size of the egg forbids the possibility of its escape without the destruction of the polypide."

From the preceding account it may be seen that there are four localities, all within the cœnœcium, devoted to the function of reproduction. These are, the ovary on the dorsal side of the orifice; the free part of the endocyst of the cell on the abdominal side, bringing forth true buds; the attached portion lower down, giving birth only to fixed statoblasts; and the funiculus, generating spermatozoa and free statoblasts. The true buds of Fredericella and Plumatella are numerous, although only one usually matures and prolongs the stem: when two or three mature, at the same time, the lateral branches are produced. These buds grow slowly, forming the ordinary tubular cells. In some varieties of Plumatella, however, the buds mature more rapidly and in greater numbers, while the branch assumes a lobe-like form, the polypides, with the cells but half developed, crowding the upper surface. This mode of formation, which is only a variation of the species in Plumatella, is of generic value in Pectinatella, where the polypides are invariably arranged upon lobiform branches. In Cristatella the true buds are more numerous than in any other genus, and they mature until the cœnœcium is full grown.

The gradual increase in the number of the buds, that reach *maturity*, coincides with the decrease in the toughness of the ectocyst, and its final obliteration in the higher

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*Meyen. Isis. 1828, p. 1228.

genera; and the absolute number of the buds to the expansion of the bud producing surface. As has been shown in the preceding paragraph, the number of the buds reaching maturity, and their absolute number in each cell of Fredericella, is generally less than in those varieties of Plumatella that have a gelatinous ectocyst; and they are less, in the latter, than in the Pectinatellæ, which have no ectocyst; and less in the Pectinatellæ than in Cristatella, where the ectocyst is wanting, and where the bud producing surface is of the greatest extent.

Composition of the Endocyst.

In the foregoing remarks the anatomy has been discussed, so far as was necessary, in order to give clearness to the descriptions of the different genera and the subsequent notice of the modes of reproduction. It now remains to consider more fully the composition of the body, together with the relations and functions of the various organs.

The endocyst is made up of four layers: (1) an outer large celled membrane (Pl. 11, fig. 1, E′, Pl. 12, fig. 2, E′, Pl. 13, fig. 16); (2) an inner one of smaller cells (Pl. 11, fig. 1, E″); (3) one of muscular fibre (Pl. 11, fig. 1, E‴); (4) an epithelial layer lined internally with muscular fibre (Pl. 11, fig. 1, E⁗).

(1) The first membrane forms the external surface of the endocyst of the polypide and of the cœnœcium.

The cells on the cœnœcia of Fredericella and Plumatella are hexagonal containing a large brilliant nucleus and nucleolus (Figs. 3, 5). Their upper sides are depressed by the weight of the superincumbent ectocyst, and their longitudinal diameters are not so long as in the cells of the same membrane on the evaginable endocyst.

When fully expanded on the living cœnœcium the cells are closely pressed one against another; but, if treated with alcohol, they contract, and, separating from each other, leave wide intervening spaces (Fgs. 2, 4, 5). These spaces have been figured by Prof. Allman under the impression that they were anastomosing channels, perhaps blood channels; my observations, however, have been too numerous to leave any doubt of their being what I have stated. The larger cells are continually multiplying by division, and there result numbers of small cells which lie scattered here and there in the supposed blood channels. Fig. 3 shows a large cell undergoing the process of division, and below, near the right lower corner of the figure, there are two minute cells, undoubtedly created in a similar manner, occupying the interstices of the membrane. Fig. 5 shows a group of cells taken from a point nearer the orifice than those of fig. 2, and, also, from a different zoöid. These are not so disfigured by contraction and have more angular outlines. Fig. 4 shows a group of five cells, from another zoöid, more highly magnified than either of the above, and more widely separated. When the cells are so dispersed the intervals are usually more or less filled in by minute cells; but, in this instance, the spaces were vacant and the nucleus of immense size, the nucleolus not being visible.

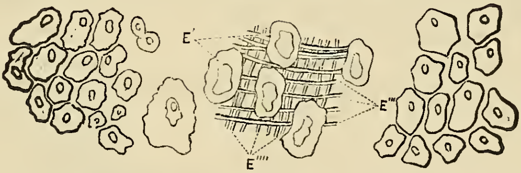

FIG. 2. FIG. 3. FIG. 4. FIG. 5.

FIGS. 2 and 5, groups of cells of the first membrane, greatly enlarged, from the cœnœcium of PLUMATELLA VITREA.

FIG. 3, one cell still more enlarged showing nucleus and nucleolus.

FIG. 4, E', cells of first membrane: E''', muscular fibres of the third layer: E'''', muscular fibres of the fourth layer.

The cells on the cœnœcia of Pectinatella and Cristatella do not differ sensibly in their structure from those of Fredericella and Plumatella. The outer sides, however, being free from the presure of an ectocyst, are more convex; and the longitudinal diameters, instead of being less, are greater than in the cells of the same membrane in the evaginable endocyst. Plate 13, fig. 16, and figures 7, 8, E' present lateral views of the membrane in the cœnœcia of Cristatella and Plumatella: in figure 8 the cellular structure is not given, but the relative thickness of the membranes may be estimated by a comparison of the two figures. The cells of the first membrane of the evaginable endocyst do not vary essentially from those on the cœnœcium, except in being greater or less than the latter, as mentioned above, and in having the power of expanding and contracting their parietes. They may swell to twice or three times the normal size, and contract again with considerable quickness, as if they had collapsed after parting with their fluid contents. From the evaginable endocyst they can be followed into the calyx, which, in the adult, is merely a web like fold of the first membranous layer; and from the calyx into the external ciliated membrane of the tentacles.

The cells on the calyx and tentacles are of about the same size as those on the evaginable endocyst, but they are not so distinctly hexagonal, unless contracted. The outer sides are more convex, than those on the cœnœcium; this peculiarity is, also, shared by the cells of the evaginable endocyst. The nucleus is large and brilliant. The nucleolus was not defined. The cilia are prolongations of the walls of the cells; each cell bearing one long slender hair (Fig. 6).

Fig. 6, two living cells, with cilia, from near the tip of a tentacle of FREDERICELLA REGINA.

The vibrations of the cilia are not constant, and, if a tentacle be severed and quickly placed under the microscope, those that are at rest can be viewed without difficulty throughout their entire length.

The cells become smaller on the lophophore, forming a denser layer than on the other parts of the zoöid. There is no break upon the edge of the œsophagus and the cells of the first membrane are continuous with the cells of the innermost layer of the alimentary canal.

(2) The second layer is made up of smaller cells. It is

coextensive with the first, and is the principal membrane of the endocyst. The size of its cells does not vary appreciably within the limits of the group. As a general rule, however, its thickness in the cœnœcium is quite double what it is in the evaginable endocyst, and on the outer side of the tentacles. On the inner side of those organs, and in the lophophore, it becomes as thick as it was in the cœnœcium. In the arms, also, it is thicker than in the evaginable endocyst; but its greatest development in this respect is attained in the region of the sphincter muscles (Fig. 8, E″). This membrane is thicker than the first membrane in the other parts of the cœnœcia of Fredericella and Plumatella, but thinner than the first membrane in the cœnœcia of Pectinatella and Cristatella (Figs. 7, 8, E″).

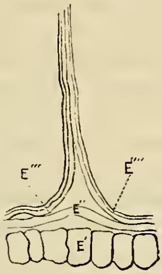

FIG. 7, base of a cœnœcial wall of a living specimen of CRISTATELLA OPHIDIOIDEA viewed from the base, the specimen being inverted: E', first membrane of the endocyst: E'', second membrane of the endocyst: E''', third layer of transverse muscular fibre: E'''', epithelial membrane with longitudinal muscular fibres.

(3) The third layer is exceedingly contractile. The transverse fibres of which it is composed are loosely and irregularly set, but have considerable muscular power (Figs. 4, 8, E‴). The cœnœcial endocyst of Plumatella is sometimes drawn in by annular constrictions, happening, apparently at will, in any part of the wall where the ectocyst is sufficiently pliable, which are generally referable to the action of this muscular coat. Such annular constrictions can be occasionally traced to rows of small muscles extending across the cavity from the endocyst to the alimentary canal, or to the invaginated fold. These muscles, however, could not have been the cause of the constrictions in the dead Plumatella Arethusa figured in Pl. 8, fig. 10. The most careful observations of this specimen, with a high power, failed in bringing to light any such rows of muscles, and, in this case, all the plications, with the exception of those brought about by the influence of the retentor muscles (Pl. 8, fig. 5), were due to the transverse annular muscles of the third layer.

An involution of this layer aids in forming the base of the walls in the cœnœcium of Cristatella (Fig. 7, E'''), but it does not probably extend into their reticulated portion (Pl. 14, fig. 1, Q). Judging from the thinness of the latter, and, from the fact, that all the longitudinal muscles of the body appear to be connected more or less with the fourth or epithelial membrane, it is quite likely that the reticulated portion, or those parts of the cœnœcial walls which lie between the junctions of the walls with the upper and lower internal surfaces of the cœnœcial endocyst, are composed wholly of longitudinal fibres, encased by the epithelium. Around the invaginated fold of Plumatella the fibres are thickly disposed and form the so called sphincter muscle. This is not a narrow band, as described by Prof. Allman, encircling the lower edge of the fold, but a local development of the transverse fibres, as broad as the fold itself (Fig. 8, E''').

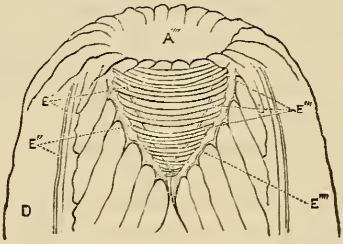

FIG. 8, Magnified view of the Invaginated fold of a living specimen of PLUMATELLA DIFFUSA.* A'''', cœnœcial orifice: D, ectocyst: E', first membrane of the endocyst: E'', second membrane of the endocyst: E''', third layer of transverse muscular fibre, constituting the Sphincter muscle. E'''', fourth or epithelial layer, accompanied by longitudinal muscular fibres.

In the evaginable endocyst this layer can be seen, by careful focussing, through the fourth membrane, but only with ease, when more or less contracted.

In the arms and lophophore it is thick, and frequently, in the former, becomes convoluted by the action of muscular bands apparently developed in its substance. I was unable to trace this membrane in the tentacles, but judging from the great thickness of the second tentacular membrane, and the slight increase which takes place in the transverse diameter of those organs when

*NOTE. Only three membranes are delineated in the cœnœcial endocyst of figure 8. This is owing to my want of success in defining the parts of the innermost layer, in the specimen figured, which is undoubtedly made up of two layers, as in the cœnœcium of Cristatella (Fig. 7, E''', E'''').

drawn in, as they often are, to less than one third of their full length, I have ventured to assume that it also exists there (Pl. 11, fig. 1, E''').

(4) The fourth or epithelial membrane, lines the interior, investing all the muscles and the digestive system. It is ciliated upon the perigastric region, and upon the interior of the arms and lophophore, but not in the tentacles or upon the alimentary canal. On the abdominal side, a double layer, or fold, of this membrane, which I have named the Brachial Collar, constitutes a partial diaphragm reaching about half way round the œsophagus. On the dorsal side it is disconnected from the lophophore, and hangs into the perigastric space, partitioning off the inside of the epistome, and a space below in which the ganglion is suspended. There are numerous fibres upon the inner side of this diaphragm attached to the œsophagus and endocyst, between the bases of the arms, having sufficient contractile power to deeply infold that part of the body wall.

Prof. Allman mentions but two membranes in the endocyst, one, an outer large celled layer, equivalent to my first and second membranes, and another, an inner layer, equivalent to my third and fourth membranes. Throughout its whole extent, the fourth or epithelial layer is lined by muscular fibres. These cross the transverse fibres of the third layer at right angles (fig. 4, E''''). and both were regarded by Prof. Allman as a single inner layer of reticulated muscles. The longitudinal fibres, however, are invariably next to the fourth membrane, and remain attached to it, whenever, as in the neural diaphragm, it parts from the other layers. The transverse fibres, also, never seem to be connected with the longitudinal, wherever a good definition of either has been obtained. No transverse fibres are visible on the neural diaphragm; and on the invaginated fold (Fig. 8), and the œsophagus (Pl. 11), no longitudinal fibres are visible.* In the two latter they are

*Note. Since the printing of the plates, I have, in reviewing these pages, changed my opinion and now estimate the longitudinal fibres, as of equal importance with the transverse, and consider them a fourth layer of muscular fibre, the epithelial becoming a fifth membranous layundoubtedly present, being occasionally seen in a direct view; but, when looked for in a lateral section, they are too diaphanous and closely adherent to the fourth membrane to be defined. Their incorporation with this membrane will also be justified by the description of its functions in connection with the alimentary canal of Pectinatella.

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er. The endocyst is consequently made up of three membranous and two muscular layers; all the specialized constricting muscles of the body being derived from the third layer, and all the longitudinal from the fourth layer of muscular fibre.

The inner and outer tentacular bands, as will be presently shown, are inseparable from the latter layer. The retractors, also, notwithstanding their disc like structure, can hardly be distinguished from the numerous abnormal bands, that occur in some species, connecting the endocyst and alimentary canal. These undoubtedly belong to the fourth layer, and the retractors may, therefore, be looked upon as having the same relation to the fourth layer that the sphincter has to the third.

The peculiar arrangement of the third and fourth layers retains the form of the parts, and gives stability to the entire endocyst. By the contraction of the third and relaxation of the fourth the transverse diameters of the parts may be decreased, and the longitudinal increased; or, by the opposite process, the longitudinal may be decreased, and the transverse increased. During the invagination of the polypide, the fibres of both are in a state of contraction in the evaginable endocyst and in the region of the sphincter; in the cœnœcium, however, they are relaxed. But as soon as evagination begins, they appear to reverse this condition. The cœnœcial fibres become contracted and those of the same layers in the polypide are stretched to their full length. By these reciprocal changes they materially assist the compressed fluids of the body in forcing out and expanding the polypide. I have, also, had reason to doubt the existence of a neural diaphragm. In examining a specimen of Fredericella regina from the side and from above, under very favorable circumstances, I was unable to detect the same appearance of an enveloping membrane just below the nerve mass, that led me to the conclusion mentioned; nor have I had any opportunity of verifying my first observations on Pectinatella, which, however, were faithfully made with one of Tolle's one half inch objectives. Until therefore, Fredericella is shown to be exceptional in this respect by further observations on other genera, it is, perhaps, best to regard the existence of a neural diaphragm as doubtful.

[TO BE CONTINUED IN VOL. V.]