SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

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LUCERNARIÆ

AND THEIR ALLIES.

A MEMOIR ON THE ANATOMY AND PHYSIOLOGY

OF

HALICLYSTUS AURICULA,

AND OTHER LUCERNARIANS,

WITH A

DISCUSSION OF THEIR RELATIONS TO OTHER ACALEPHÆ; TO BEROIDS, AND POLYPI.

BY

HENRY JAMES CLARK, B.S., A.B.

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ADVERTISEMENT.

The following Memoir relates to a group of animals of a somewhat octagonal bowl-shaped form (not unlike that of a reversed umbrella), with tentacles clustered in groups at each of the angles. These animals, formerly regarded as a group of the Polyps, related to the sea-anemones, have in more recent times been associated with the Acalephs or sea-nettles and jelly-fishes, and either combined with one of the more comprehensive orders, or estimated as representatives of a peculiar and independent order. This group, which was the subject of Professor Clark's last studies, is in his judgment entitled to ordinal rank in the class of Acalephæ. The first part of the work is occupied with the "general and comparative morphology" of the Lucernariæ; and the second part is restricted to the "anatomy and physiology of *Haliclystus auricula.*" In the first part are three chapters; the first on "individuality," in which are considered the questions relating to "polarity and polycephalism," and "the hydroid and medusoid cephalisms." In the second, the thesis that "the type of form is not radiate" is defended, and the form is described as "the dorso-ventrally repetitive type." The third chapter is devoted to the consideration of "antero-posterior (cephalo-caudal) repetition," and under the heads of "the scyphostoma and ephyra varieties of the same morph" and "the individuality of Pelagia and Lucernariæ."

In the second part are four chapters, the third to seventh of the entire work. In the first (third of the work) are described the "general form and structure," including habitat, habits, form, and size, the proboscis, the umbella, and the peduncle In the second is considered the "organography, including the walls," "the muscular system," "the tentacles, the marginal adhesive bodies, or colletocystophoræ," "the caudal adherent disk," "the digitiform bodies, or digituli," "the digestive system," "the nervous system," and "the reproductive system."

In a third, are embraced the results of studies of the "embryology," or various stages of growth of the species, including observations on "the egg and the spermatozoa;" on "a young *Haliclystus auricula*, nearly one-sixteenth of an inch in diameter;" on "a specimen three thirty-seconds of an inch across the umbella;" on "a young specimen one-eighth of an inch across;" on the "special development of a tentacle, a colletocystophore, and a genital sac;" on the "young one-fifth of an inch across;" and on the "young six twenty-fifths of an inch across."

In a fourth chapter, in an "histology of *Haliclystus auricula*," the tissues of the several parts of the body are considered—that is, "the umbellar and peduncular walls;" "histology of the tentacles;" "histology of the colletocystophores" (anchors); "histology of the caudal disk;" and "histology of the digituli" and "the prehensile cysts" (nematocysts and colletocysts).

With profound regret, we have to announce that before the completion of the engraving of the necessary plates to illustrate his work, Professor Henry James Clark was called from this life, in the flower of his age, and in the midst of a series of successful investigations.

The publication of this memoir has, consequently, been greatly delayed. The reading of the proofs and supervision of the work were kindly undertaken by Professor A. E. Verrill, of Yale College, who has, however, himself been much hindered in his work by ill-health and other causes. In editing this memoir he has not thought it desirable to make any changes, except verbal and typographical ones, which would not alter the meaning of the author. This has been carefully adhered to in all cases, even where changes would, perhaps, have been made by the author himself, had he lived, in consequence of the advance of knowledge during the several years that have elapsed since the memoir was written. Owing to the fact that the plates, with one exception, were engraved in Paris, and no proofs were submitted for correction, several errors, noticed in the explanations, were made in the lettering. These might lead to mistakes, in some cases, unless their existence be noted.

The following extracts from a Memoir of Mr. Clark, read by Professor A. S. Packard, Jr., before the National Academy of Sciences, in 1874, will be of interest to the readers of the present work:—

"Within the year past we have lost a member who may be said, without disparagement to others laboring in the same field, to have been the foremost American histologist and microscopist, and one of our most skilful and accomplished biologists; one the rule of whose scientific life was a practical application of experimental philosophy. A true naturalist, he was an enthusiast, and yet in his methods of study severe, exact, and in all respects scholarly.

Henry James Clark was born June 22, 1826, at Easton, Massachusetts. Of his early life little information has been obtained, except that he was fond of drawing, an art which proved of much service and credit to him in after years.

He received his collegiate education at the University of the City of New York, graduating in 1848.

His first love for science seems to have grown from his fondness for flowers. Immediately after leaving college he taught for some time at White Plains, New York. While there, in some of his out-of-door rambles—and he was fond of taking long walks—he found a flower which he thought was new. On returning home he ascertained that it was not described in Professor Gray's Botany. He at once began a correspondence with Professor Gray in regard to it, and eventually received an invitation from him to go to Cambridge. He went there as a student of botany, under Professor Gray, in 1850, and this may be regarded as the date of his scientific birth. While a student at the Botanic Garden, he taught in the Academy at Westfield, Massachusetts, for a single term, apparently achieving much success as a teacher, and forming life-long friendships.

Soon after this he became a student of Professor Agassiz; but his love for botany never diminished. He studied it in after years from the side of vegetable histology and morphology in connection with and as illustrating the histology and morphology of animals. The influence of his knowledge of botany on his zoological studies was marked. It prepared him for his studies on spontaneous generation, on the theory of the cell, on the structure of the Protozoa and the nature of protoplasm. In studying the lasso-cells of the Acalephs, he traced their analogical resemblance to the stinging hairs of the nettle. By his intimate knowledge of the spores of the smaller Algæ, he was able to point out some of the characters separating the lowest Protozoa from the spores of plants, and aid in the work of Thuret and others in eliminating from the animal kingdom certain vegetable spores which had been originally described as infusoria.

His first scientific paper was on a botanical subject, 'The peculiar growth of rings in the trunk of *Rhus toxicodendron*,' published in 1856, and this was supplemented by unpublished studies on the eccentricity of the pith in *Ampelopsis quinquefolia* and *Celastrus scandens*. In his walks he often botanized, and contributed in this way to Gray's botanical text-books. Thus with the training he received from Professors Gray and Agassiz, he looked upon the world of organized beings from both the botanical and zoölogical sides. He well deserves the name, *biologist*.

He graduated from the Lawrence Scientific School in 1854, taking the degree of B. S. He was for several years the private assistant of Professor Agassiz, who, early in 1857, spoke of him enthusiastically, remarking to a friend, 'Clark has become the most accurate observer in the country.' Between 1856 and 1863 he was associated with Agassiz in the preparation of the anatomical and embryological portions of the 'Contributions to the Natural History of the United States.' Here his great skill and delicacy in the use of the scalpel and pencil won much praise from naturalists. Nearly all the plates in the Contributions, illustrating the embryology and histology of the turtles and Acalephs, are signed with his name.

The drawings were not only beautifully worked up, but possessed the merit of extreme accuracy.

In the use of the microscope, Clark showed not only mechanical skill and ingenuity, but a patience, caution, and experience in difficult points in histology, which undoubtedly placed him at the head of observers in this country, and rendered him, perhaps, inferior to few in Europe. He used the highest powers with a skill that few if any living observers have surpassed. He suggested improvements, carried out by Spencer, at the instance of Professor Agassiz, in this instrument. After leaving Cambridge he studied the Infusoria and lower plants, and made drawings and notes, comprising descriptions of many new forms of Infusoria. He planned an extensive work upon this subject, portions of which are now in charge of the Boston Society of Natural History for publication. The drawings are of great delicacy and beauty, and, had he lived to complete the work, it would doubtless have been equal to if not in advance of Claparède and Lachman's famous work on the Infusoria. He did not dissociate the Protophyta from the Protozoa, regarding them as almost inseparable in nature; thus, as we have ascertained, in his lectures to his classes, well nigh anticipating Haeckel's classification of the lowest forms of the animal and vegetable kingdom into the Protista and Protozoa.

In June, 1860, he was appointed adjunct Professor of Zoölogy in the Lawrence Scientific School, which he held until the expiration of his term of office; and, in the spring and summer of 1861, gave a course of lectures on histology at the Museum of Comparative Zoölogy. In the spring of 1864 he delivered a course of twelve lectures at the Lowell Institute in Boston, which were published in the same year, under the title of 'Mind in Nature; or, the Origin of Life, and the Mode of Development of Animals.' This is, in all respects, for its usually sound and clear thinking, its breadth of view, and the amount of original work it contains, perhaps the most remarkable general zoölogical work as yet produced in this country. If the author had left us no other work, this alone would testify to years of the severest labor and independent thought. It anticipated certain points in histology, and the structure of the Protozoa and Sponges especially, which have made the succeeding labors of some European observers notable.

In December, 1866, he was appointed Professor of Botany, Zoölogy, and Geology in the Agricultural College of Pennsylvania. He resided at Centre County, Pennsylvania, the seat of the College, until April, 1869, when he was appointed to the Chair of Natural History of the University of Kentucky. He lived at Lexington, Kentucky, until February, 1872, when he was elected Professor of Veterinary Science in the Massachusetts Agricultural College.

During this period he suffered much from sickness; still he managed in intervals of college duties to produce some remarkable memoirs. In his first paper on

Actinophrys (1863), he discovered that 'all vibratile cilia originate in the amorphous intercellular substance,' and do not form direct prolongations of cells. In 1864, appeared a brief paper, in which he showed that Tubularia was not parthenogenous, having found, by the aid of Tolles' improved quarter of an inch objectives, that it produced eggs. Perhaps the most important work he has done is in his studies on the affinities of the sponges. In November, 1866, appeared, in the American Journal of Science and Arts, a brief paper, entitled 'Conclusive Proofs of the Animality of the Ciliate Sponges, and of their Affinities with the Infusoria Flagellata.' While he had in his Lowell Lectures endeavored to show that there was a unity of plan in the organization of the Protozoa, their bodies being arranged in the form of a helix, he now endeavored to show that the sponge did not depart from the protozoan type. By the discovery of a remarkable form (Codosiga) he was enabled in it to trace a link, in his opinion, uniting the sponges with the flagellate Infusoria, such as Monas, Anthophysa, and Codosiga. In the full memoir, which was published a year after, with numerous figures, under the title 'Spongiæ Ciliatæ as Infusoria Flagellata,' he attempted to establish the homology of the flagellate cells, constituting the tissues of the sponge, with the flagellate Infusoria. He demonstrated, by the use of the superior objectives made by Tolles, that these cells are like Monads, with contractile vesicles, nuclei, a collar, and flagellum; that the sponge was in fact a compound monad, and not a compound amœba, as insisted on by Carter in 1854–57, and Lieberkuhn in 1856 and 1857. This was a great step in advance of previous observers. Certainly an organism with cells so highly differentiated as those in the sponge cannot be a plant, and while, as Clark observes, Carter had 'been the first to present anything like decisive proofs of the animality of the sponges,' yet this was confirmed and demonstrated still more completely by Clark himself. In this memoir he insists upon the fact that these simple 'monas-like infusoria,' making up the compound body of the sponge, were undoubtedly endowed with a distinct mouth, afterwards, in 1871, distinctly seen; while Carter described them as engulfing food like an amœba, any part of the cell acting as a mouth. Of course it is necessary for our author to prove that Monas is an animal. This he does conclusively, showing it has a distinct mouth, with a 'lip,' into which food is thrown by the flagellum. The cells or zoöids of the sponge (*Leucosolenia*) agree with Monas in all respects, except that he did not detect the mouth, though he saw currents of floating particles which 'are constantly whirled in by the flagella and made to impinge upon the area within the collar.'

The study of the sponges has since the publication of this important memoir been pursued by Oscar Schmidt, Miklucho Macleay, and Ernst Haeckel. Considerable advance has been made regarding the organization of the adult, while the young of the sponge has been proved to be like the planula of a radiate, and made up of two layers of cells.

The last paper he published was entitled, 'The American Spongilla, a Craspedote, Flagellate Infusorian,' in which he criticizes Haeckel's views on the affinities of these animals, and insists upon their affinities to known Flagellate Infusoria This was published in December, 1871, in the American Journal of Science and Arts.

Busy with his work at Amherst, and struggling with the fatal disease (tabes mesenterica) which was rapidly reducing his bodily strength, he wasted away, and died on the first day of July, 1873, in full possession of his mental faculties. He left a wife, seven surviving children, and many warm friends to mourn his loss.

He was a man of the warmest sympathies, a devoted and affectionate husband, a loving brother, and dutiful son; in many respects an admirable teacher, as a lecturer clear and systematic, with an enthusiasm that evinced the true naturalist. The secret of his success as an investigator may be stated in his own words taken from his diary, where he says he made it a rule to practise the 'utmost rigidity and thoroughness in his researches, without regard to time consumed or the value of the results.' He had the best of teachers, and he made the most of his opportunities. We may look upon the results of his work as elevating the standard of American scientific work.

He was a member of most of the learned societies in this country, while his works have been recognized and referred to by some of the leading zoölogists in Europe."

JOSEPH HENRY,
Secretary Smithsonian Institution.

WASHINGTON, D. C., APRIL, 1878.

PART I.

GENERAL AND COMPARATIVE MORPHOLOGY.

CHAPTER I.

INDIVIDUALITY.

§ 1. *Polarity and Polycephalism.*

1 To those readers who are acquainted with the literature of *Acalephæ* there will very naturally arise, first and foremost, the question as to our theory concerning the individuality of these polymorphic beings. This is a point upon which we feel necessitated at the outset to take a definite stand, in regard to the *Acalephæ* as a whole, and in reference to the *Lucernariæ* in particular. We have already, in a general work[1] upon the development, morphology, and classification of animals, entered our protest against that theory of individuality which assumes that the medusoid genitalia of Hydromedusæ should be considered as individuals in a higher sense than the hydræ are, no matter to how low a degree of development they descend nor at how high an elevation they arrive in the complexity and differentiation of their parts. We still adhere to that protest as far as the hydræ and medusoids are related to each other; but look upon them both in a modified light in reference to their individuality.

2 We suppose it will not be questioned that in the main, naturalists and physiologists have always defined in their own minds, and in their teachings, the zoölogical *individual* to be a *monocephalic* being; that they have taken as their standard the most highly developed creatures of the animal kingdom, whose *oneness* and independence place them on an equal footing with man in these respects. In the discussion, of late years, upon the individuality of the lower, compound, colonial denizens of the water, the main points at issue have always been to determine whether a certain form was, on one hand, an *individual*, either in its highest sense (a monomeric, independent integral) or one of several independent individuals which constitute a colony (a polymeric integer), or, on the other hand, was an *organ*, which formed only a part of an individual, whether the

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[1] Mind in Nature, or the Origin of Life and the Mode of Development of Animals. New York, D. Appleton & Co., 1865.

latter be monomerous (as in Hybocodon and Corymorpha producing free medusæ), or polymerous (as in Coryne with free medusæ).

3. The possibility of a third category of individuality had not arisen in the minds of philosophic naturalists until the question of the bilaterality of the two lower grand divisions of the animal kingdom had been discussed so vigorously, and elevated to such a prominence among the theories of the day as to extend its influence even to the determination of the oneness or duality of the members of the highest of all grand divisions, and indeed the highest of all animals, man himself. Here, at this point, we find breaking in upon us the Teratological essays of St. Hilaire, and the more recent decisions of Wyman upon the same subject, with the strange confirmations of Lereboullet, by his discoveries of the fissigemmation of the piscine egg, and the evolution of two heads or two tails from one centre of development—the *dualistic* tendency of the highest vertebrate emphasized by the presentation of the living tangible reality.[1]

4. Such possibilities among the Vertebrata staring us in the face could not but send the thoughts flashing back among the inferior, less determined, less differentiated organizations; and the mind's eye needed not to dwell long among the many-headed Vorticellæ, Polypi, Hydromedusæ, Bryozoa, Ascididæ, Pyrosomidæ, Salpæ, etc., before discovering a multitude of more than shadowy tendencies; it became fixed upon numerous sharply and clearly established, unmistakable dualities and pluralities; all arising from one common centre, the *ovum.* Had we not the problem of plural individuality solved here—*a polycephalism—?* the diffuse vitality of the animal-egg of the lowest ranks of life outspoken in the indetermined number and localization of the subdivisions of the Polyp or Hydromedusa corporation; and even the organization itself undecided[2] as to whether it should exemplify its oneness in a simple unit of form, as in the *pseudoindividuum* of Bryozoa, Ascidiadæ, or resolve its offices and configuration into the repetitive, multiplied sameness of the sexless and sexual *proles* of Salpæ, Tæniæ, Annelidæ, and Hydromedusæ, or the excessive repetitions of the genitalia of Polypi.

5. The old type of monomerism, the vertebrate individual *par excellence,* has then become the modern, more than transcendental *duality.* The originals of multitudes of figures in St. Hilaire's "Teratologie," of the memoir of Lereboullet, and of the condensed aphoristic sketches of Wyman stand forth the real, material embodiments of the idea upon which all sentient life is founded. *Bilaterality* does not express the thought, it embraces too little; it is to be classed with anteroposteriority and dorso-ventrality, to signify the *subdominant* features of the animal architecture; features which evolve themselves as the concomitant resultants of the development of the primitive dominant which originally gave shape to the *bipolar ovum.* The embryologist, and to his thoughts the subject is most germane, reflecting upon the physical aspect of the forming egg, would naturally arrange its features in two antagonistic fields; and thereupon attempting to define their position in regard to the contour of the concrete sphere, almost inevitably would

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[1] See remarks of the author on this subject in "Mind in Nature," ut sup., p. 1.

[2] See paragraphs 22 and 23.

give utterance to the word *polarity*. This is the dominant, main idea of sentient life.

6. It is *polarity* which is evinced when the self-dispersing, self-repellant potentiality of the animal-egg lays down the right and left of the germ on opposing sides of a line; when the cephalic and caudal areas grow in opposite directions from a common point of emanation; or when the animal and vegetative foundations project themselves into diametrically diverse, dorsal and ventral spaces. Each and all of these phenomena have a common point to rest upon; and they proclaim, by their mode of operation, the controlling influence of a power which, fixing itself upon that point, as it were, radiates itself through the whole organism, and disposes its several features in such a way that they all display, either in mode of evolution or by a direct connection, a polar tendency; a growing out of one pole and a dispersion toward the opposite one; features most developed and decided in configuration next the point of departure, and least developed and most diffuse and indeterminate in the opposite area; the latter always through life standing in the same relation to the former as supply does to demand, as nutrition does to the power which regulates the absorption of the nutriment.

7. But *bilaterality* carries with it something more than the mere dextral and sinistral opposition of the lateral halves of the body; it is not merely the bipartition of a *unit* of form; for the distal as well as the proximal edges of these halves—the free borders and the margins of contact—are mutually interchangeable; the former may take the place of the latter, and yet leave the apparent bipartite unit undisturbed in internal relations.

8. *Antero-posteriority* exhibits the same interchangeability as bilaterality, but, although plainly enough, not so conspicuously in a comparative, homological sense as in the physiological interplay of the functions, such as we see in the relations of the allantois to respiration in the embryo, or in the ratio of excretion of the renal organs dependent upon the degree of activity of the respiratory and perspiratory functions; or in the relation of the reproductive organs to the vocal and respiratory, when the former are in an abnormal condition, or when they change from one period of life to another, from youth to adolescence; and in many other interdependent relations familiar to the morphologist of the present day.

9. Bilaterality, antero-posteriority, and dorso-ventrality, the three principal *subdominants of polarity*, have a very methodical disposition, and are quite pronounced and sharply defined among the higher groups of animals--the more seemingly *units* of organization—but if we go to the opposite extreme of grade we shall find among the lower classes of life, that the polaric element (like the differentiation of organization, and that of function) is in an almost elementary condition, expressing itself vaguely in the scattered heads of a branch of Coryne, or Tubularia, or Clavellina; or a little more determinately in the distichous arrangement of the hydra heads of Dynamena and Sertularia, or in the singularly stellate disposition of the zoöids of Botryllus, with their common cloacal orifice.

10. When, however, polymerism, in its usually accepted sense, fails, as it does step by step in the gradually rising degrees of rank, polarity gains the ascendency in point of regularity and the closer intimacy and symmetrical arrangement of the

components of the organization which it holds sway over. Thus it is that two, or more, scattered, consimilar parts, or complete organizations may combine to form a seeming *one*, an apparent, bipartite or multipartite *unit*. The multiple repetition of heads among the lower polymeric kinds is here reduced to a dual repetition, and the parts condensed into one form an approximative unit, a zoölogical *individuum*, as the highest expression of unity attainable by the vertebrate *zoön*.

11. The duality, nay the plurality of the subdivision of the vertebrate axis, as illustrated by the embryo fishes of Lereboullet, is recalled in the diffusiveness of the many hydræ of the dendritic Campanulariæ, and is disguised under the interminable heteromorphism of the Siphonophoræ; it is polymerous but dimorphous in Salpa, or polymerous but monomorphous in the fresh-water Polyzoa; temporarily a polymerous, monomorphic *individuum* in the fissigemmating Hydra, it eventually resolves itself into disconnected *pseudo-individua*; for a time polymerous, but dimorphic, in the annelidan Myrianida of Milne-Edwards, it finally assumes the appearance of a true, self-contained *individuum* in each one of the separate, independently moving *sexual segments*, and in the original budding-stock (the direct legitimate offspring of the egg) from which they shot forth.

§ 2. *The hydroid and medusoid Cephalisms.*

12. Under the term *cephalism* we include two forms, or *morphs*, viz., (1) the *cephalid*, or such subdivisions of a body as have a complete organization, whether united in common (as in Spongidæ,[1] some Vorticellidæ, Corals, Bryozoa, some Ascididæ, and Pyrosomidæ), or separating singly from the main stock (as in Hydra and Actiniæ); and (2) the *cephaloid*, or those divisions of a fissigemmating body which do not contain a complete organization, and may be either mostly *sexual* (as the so-called medusæ of Hydromedusæ, or the posterior divisions of Myrianida and other worms, or the joints of Tænia, or the Cercaria-brood of Distoma, or the chain of Salpa), or mostly vegetative and *sexless* (as the hydræ of Hydromedusæ, the Myrianida stock, the head of Tænia, the single, budding stock of Salpa, or the budding Cercaria-nurses of Distoma).

13. The thorough historian of the multifarious, so-called alternate generations of the Acalephæ will see nothing but a generative organ in the spermatic and ovarian sacs of Hydra; and detect nothing more in the grape-like clusters about the base of the head of Clava, or in the grouped moniliform projections behind the corona of tentacles of Eudendrium. The polymerism of these organs of Eudendrium is nothing more than a repetition of the simple sac of Clava; the diversity in form is only apparent. But one step higher in complexity and the observer will find in the tentaculiferous terminations of the reproductive sacs of Thamnocnidia and Parypha a premonition of a forthcoming *cephalic* independence, such as is already fully exemplified in the many hydras of the polymeric, dendritic mass. A similar progression toward cephalic freedom will

[1] See the author's memoir on "Spongiæ Ciliatæ as Infusoria Flagellata;" Memoirs Boston Soc. Nat. Hist., Vol. I, 1867.

also be seen in the simplest generative sacs of Laömedea amphora, L. flexuosa, etc., and, in other forms, rising through successive degrees of complexity to those of Gonothyrea (Laomedea) Lovenii *All.*, which are not only tipped with tentacular processes, as in Parypha and Thamnocnidia, but have within them a series of longitudinal tubes, like those in the homologous organ of Tubularia indivisa.

14. Gradually and methodically the progressive steps of complication lead on, with a more and more marked separation of the genitalia from a direct relation to the general mass, or even to the hydræ in particular, whilst a consentaneous development gathers around them and brings them into immediate alliance with an envelope whose *morph* is only a slightly varied repetition of that of the hydra, but whose greater degree of complexity gives it a better claim to be ranked as the highest among the *cephalic subdivisions* of the body. But the full aim of the train of development is not divulged here; its results only exemplify a part of it in the predominance of the reproductive function and a differentiation of the nutritive cavity into distinct channels of circulation, and the subordination of a definite region of its periphery to a tentacular, prehensile office. Step by step, however, all the elements of a complete organism are successively absorbed out of the primitive hydra-mass, and remodelled into the fashion of a medusoid; the reproductive character has become a less obtrusive feature; motion attracts attention above all others; prehension has full sway in the highly developed tentacles; and the latter point, like fingers, to the self-sustaining power of the acalephan morph in the complete organization of the longitudinal and circular chymiferous channels, opening into the receptive cavity of a highly flexible, proboscidiform *manubrium*. The preliminary processes of fissigemmation are complete; the primary genesis of the *ovum, in its integrity*, is finished; the primitive stock has become differentiated into two widely diverse varieties of one morph, the *hydroid cephaloid* and the *medusoid cephaloid.* Such is the condition at which the hydromedusaria of Corymorpha, Hybocodon, Ectopleura (Tubularia) Dumortierii, Pennaria, Coryne mirabilis, Margelis, Bougainvillia, and many Campanulariæ have arrived previous to the disintegration of their mass into the free *pseudo-individual medusoids*, and their less independent contemporary homologues, the persistent *hydroid cephalisms.*

15. The budding of the *medusoid* of Podocoryne, Lizzia, Hybocodon, and others shows that the polycephalic individual retains not only its homological identity, but also its tendency to subdivide, in both of the parts which are separated from each other. In Clava we have a *hydra* cephaloid budding both medusoid cephaloids and hydra cephaloids, and the two are persistent and form a *dimorphous* body: whereas in Hybocodon there is a *hydra* cephaloid budding only medusoid cephaloids; but these latter bud other medusoid morphs, just as the hydra of Clava buds hydroid morphs. We would remark here, in passing, that it cannot be said justly, that a *medusoid* differs from a *hydroid* essentially, because the first has reproductive organs and is the parent (direct) of the eggs; for the simple globular sacs of Clava, Hydractinia and others are just as much the genital organs of the hydroid form, as the pendent sacs along the chymiferous tubes of the medusoid of Tiaropsis, Eucope, Melicertum, etc., are the genitals of the latter. Since, now, Lizzia was found by Claparède to have no intermediate hydra-state, the whole

morph, direct from the egg, is a medusoid cephaloid; the hydra-morph is left undeveloped to the lowest degree, in fact totally fails to appear, while the medusoid differentiates to the highest degree. This is just the reverse of what we observe in Clava, Hydractinia, Hydra, etc. Between these two extremes are found all possible intermediate grades in the reciprocally proportionate development of the hydroid to the medusoid; and singularly enough they are exhibited in Siphonophoræ in an almost infinite variety of morphs, so undecided in form as to leave it sometimes absolutely indeterminable whether a certain morph shall be called a hydroid or a medusoid.

15*a*. No one holding the present prevailing views in regard to individuality would find a difficulty in seeing that the members of a chain of Salpæ are so-called *individuals*, notwithstanding they are attached obliquely end to end, and *organically* connected. Now, although in the self-dividing worm, Myrianida for example, the so-called *asexual* stock may become, by actual separation, two individuals, apparently, viz., *sexless* and *sexual*, yet once they were more closely connected organically than the Salpæ which do not separate. Is now the closer connection of the yet unseparated asexual and sexual parts of the worm to make them less distinct individuals than those of the Salpa? It would seem so, according to the advocates of individualism; and therefore the Myrianida, with its posterior string of six or seven consecutive sexual *buds*, is a *monocephalic* individual. But in the sexless Salpa-form, budding the sexual chain, we have a closer parallelism with the worm than in the chain alone, in fact an identity of relation; and yet, for all that, we would not think of calling the stock (sexless) and the chain (sexual) together one individual, with *one* head, but rather *many* headed, or in other words a *polymeric unit or individual*, of sexual and sexless *cephalisms*. Therefore, by a parity of reasoning, we ought to denominate the Myrianida and its buds as a succession or series of *cephalisms*. The fact that the worm components are more in one line than in the Salpa only makes an *apparently* more individualistic body. Among tapeworms the several heads (*cephaloids*) of the *scolex* (Cœnurus) of Tænia Cœnurus are not arranged in a line, end to end, but all are free anteriorly, and connected with each other posteriorly by a common body. The closer connection of the subdivisions of the annelid is only one of degree; and as to having more organs in common than the Salpa, it is rather like the community of interest which the coral cephalisms have in the main trunk.

15*b*. Since the sexual and sexless are necessary to make up a complete organism, *i. e.*, vegetative and reproductive, the one a complement of the other, neither *alone* can represent the *individual* unit, or whole cycle of life: and CEPHALISM is, therefore, a better term to indicate the potentiality of these subdivisions to live apart (although this does not always occur, as in corals, Bryozoa, some Campanulariæ and Tubulariæ), but when living apart (as in other Tubulariæ [T. Dumortierii], Laomedeæ [Eucope diaphana, etc.], and Salpæ, Myrianida, etc.), meaning more or less *incomplete* individuals (pseudo-individuals) which are either mainly vegetative or mainly reproductive, as the case may be. We look upon cephalism, then, on one hand as having a controlling influence of a low degree of independence when shared in common by the multiple heads of a coral polypidom, and, on the other hand, as attaining to the highest independence as a controlling power, when the multiple parts of a so-called compound individual separate from each other, and are singly under the influence of this power. The latter obtains when a Hydra or Actinia separates its buds from itself; or when the sexual part of the annelid worm subdivides from the asexual one. Cephalism of a low degree is more readily recognized in the aggregated cephaloids of Salpa than in the undivided worm; but, unlike the latter, the former remain connected cephaloids (in the chain) when separated from the budding stock.

15*c*. By thus dividing the body of a Hydromedusa into two parts, which shall contain, severally, the vegetative dominant (*i. e.*, *vegetative cephaloid*) and the sexual dominant (*i. e.*, *sexual cephaloid*), we avoid the absurdity of assigning individuality to the *egg-sac* of Hydra and others of its allies which have evidently a mere genital organ. Although we might be inclined to admit that some *cephalisms* may gradually become complete individuals, as when the buds of Actinia or Hydra separate from the parent body; on the other hand, we must insist that an *individual* cannot retain the same significance when reduced to a mere *genital organ*, as when, in Coryne, a free medusoid (Sarsia) later in the season becomes an egg-sac; or when the free medusa of Tubularia (Ectopleura) Dumortierii is represented in Tubularia (Thamnocnidia) spectabilis and Parypha crocea by a plain sac; or where, as in Siphonophoræ, a subdivision may be either a sexual medusoid, or a sexless swimming-bell, or a mere "scale."

15*d*. Farther than this we need not go in order to illustrate our views in regard to the relations of the so-called polymorphic individuals. Why we would rather look upon them either as so many diverse forms of cephalic extremities—whether hydroid or medusoid, or doubtfully one or the other, as may happen among the Siphonophoræ—or purely as organs under various disguises, may be found set forth, *in extenso*, in the chapter on the individuality of Hydromedusæ and upon the comparative individuality of Acalephæ.

CHAPTER II.

THE TYPE OF FORM IS NOT RADIATE.

§ 3. *The dorso-ventrally repetitive type.*

16. YET one word more is needed to secure to the reader a full understanding of the point of view from which we are about to consider our subject. The commonly received theory, that the so-called *Radiata* are founded upon the idea of radiation, was combated by the author some five years ago,[1] and the reasons for

[1] Mind in Nature, ut sup., p. 128.

offering a new view of the typical relations of the organism were then given in a brief sketch; too brief in fact to suffice for our present purposes In this place, however, we shall only state our position in regard to the matter, and refer to those chapters (Part XV) which are especially set apart for the discussion of the question.

17. We assume that, as in all the other four grand divisions of animals, the mouth is at the cephalic or anterior extremity of the body, and that all the rest of the organism is virtually, if not really, topographically behind it, and that whatever extends from the oral end of the body *does not radiate* from that end in two three, four, or five, or more directions, but trends posteriorly in so many lines parallel-wise to a longitudinal axis, and to a vertical sectant plane which divides the body into a bilateral figure. To give the idea a reality, we have but to point to the mouth of an Actinia as the cephalic end of our bilateral figure, and looking inwardly we shall see the flat stomach forming the sectant plane, which, extended in imagination, in two opposite directions, would strike the periphery of the body along two dorsal and ventral lines one hundred and eighty degrees from each other, and then, projected still further away from the mouth, would terminate finally in the posterior, adherent, discoid end. Parallel-wise with this plane all of the partitions of the digestive cavity trend, like a series of superposed shelves or galleries, in direct lines from the region lying right and left of the mouth, and of the flattened parallel sides of the stomach, backward along the inner face of the cylindrical periphery, so as to subdivide the included space into as many longitudinal corridors. It is these partitions which, by their multiplied sameness, constitute, among others, the elements that embody the *dorso-ventrally repetitive type;* the true ideal, as we fully believe, upon which this grand division is founded.

18. We think we shall be understood now, when we say that the multitudinous chymiferous canals of the disciform Æquorea and the quadruple channels of the cylindrical bell of Sarsia are two widely separated extremes of dorso-ventrally repetitive sameness; or that the numerous ambulacra of *Solaster* and the five of *Asterias* represent two extremes of dorso-ventral repetition, thrown forward, "into rank," to the same line with the mouth; whilst the retreating rows of *Echinus*, and the more differentiated ones of *Spatangus* and *Schizaster*, and the like, present the idea in a less disguised form, to be finally exemplified, in its fullest expression and clearness, in the elongated, vermiform *Holothuriæ*.

19. The reader, probably, will not fail to comprehend us then when we state that the proboscis of a Lucernarian lies at the anterior end of the body; that the region of the main cavity, the umbelliform part of this creature, is a great deal wider than it is long, *i. e.*, it is extremely foreshortened (no more difficult to conceive, we take it, than that the short, globose body of an Octopus or a Cirrhoteuthis is a foreshortening of the same typical elements that exist in the extremely elongated, slender body of a Loligopsis); and that the so-called *peduncle* forms a thick, cylindrical, caudal termination at that end of the longitudinal axis which lies most distant from the one where the mouth opens. Finally, we will add, that the lateral halves of the body lie right and left of a plane which passes through

two diagonally opposite, dorsal and ventral corners of the four-sided proboscis, so that two other corners and two pair of reproductive organs, as well as two partitions, stand respectively on the right and on the left.[1]

CHAPTER III.

ANTERO-POSTERIOR (CEPHALO-CAUDAL) REPETITION.

§ 4. *The Scyphostoma and Ephyra, varieties of the same morph.*

20. It would seem to be incumbent on us now to proceed at once to define more precisely the morphological and individualistic character of the Lucernariæ; but before we do that it seems desirable, in fact necessary, to prepare the way more clearly by a specific statement of our views in regard to the organization of the *strobiloid* Acalephæ, and particularly in reference to their morphology. If all the members of this order originated and developed in the same way as a certain Pelagia was observed to do by Krohn,[2] there would be neither such a thing as a strobiloid Acaleph, nor any dispute as to the strict individuality of the medusiform Acaleph; but reproduction by that method is not the only one, in fact it is an extreme between which and the more commonly known process there are no graduated means, such as exist so notably among the Hydromedusæ. In this Pelagia the scyphostoma and the ephyra are merged into one; or perhaps rather—and we only suggest the thought—the whole scyphostoma is developed from an early period directly into the ephyra, instead of first taking on a certain and quite advanced degree of complexity, and then metamorphosing itself, by self-division in part, into another variety of the same morph. It is in the latter case, *i. e. strobilism*, that we meet with a form of repetitive partition almost unknown among the Hydromedusæ; indeed we believe only to be found in the moniliform group of medusoids of Eudendrium, strung end to end.

21. In all probability the cephalic members of most of the Hydromedusæ are derived from the *bilateral* element of polarity, but in the strobiloid Acalephæ it would seem to be quite clear that *antero-posteriority* exhibits its peculiarity by an indeterminate number of *cephalo-caudal* repetitions along the longitudinal axis. We do not propose to enter here into any detailed argument to prove this, but will simply refer to the chapter (Part XI) on individuality for the minutiæ, and merely state the facts which lead us to this conclusion, without further comment.

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[1] See the section on the "Criterion of Symmetry," in Part XV, for proofs of the correctness of the above view in regard to the position of the dividing plane.

[2] See Krohn, "Ueber die frühesten Entwickl. der Pelagia noctiluca," Müll. Archiv, 1855, p. 491, Taf. XIX.

22. It most frequently happens at the beginning of the fissigemmating period, just after the scyphostoma has developed to the proper condition, that, excepting the original one bearing the anterior corona of tentacles, all of the successive segments across the longitudinal axis are medusoid in character, and immediately after these, and while they are far from being fully prepared for an independent existence, a scyphostoma-like corona of tentacles develops into an exact repetition of the foremost one; but after this first crop of ephyræ has disappeared, it is a common occurrence to meet, in the succeeding crops, with a heterogeneous mixture of ephyræ, ephyroid, doubtfully ephyroid, or doubtfully scyphostomoid, scyphostomoid, and scyphostoma forms. Sometimes two or three scyphostoma coronæ succeed each other (see Agassiz, *Contributions to the Natural History of U. S.*, Vol. III, Pl. XI), or two or more lie behind the ephyræ (Ag., *Contrib.*, Pl. XI, *fig.* 16). Again a scyphostoma corona, following a series of ephyræ, has eye-spots at the bases of the tentacles (Ag., *Contrib.*, Pl. XI, *fig.* 5), or the edge of a segment is made up of alternate broad and narrow lobes, the first terminating in single, and the latter in three scyphostomoid tentacles (Ag., *Contrib.*, Pl. XI, *fig.* 19), thus imitating the ocular lobes of the ephyræ in relative position, and their composition in an exaggerated form, leaving it altogether uncertain whether the segment belongs to the scyphostomic or the ephyra morph; or again a number of ephyroid segments have their ocular lobes either tipped with scyphostomic tentacles (Ag., *Contrib.*, Pl. XI, *figs.* 15 and 22), or the latter are superadded close to the base of the ocular peduncle (Ag., *Contrib.*, Pl. XI, *figs.* 8, 14, and 16).

23. This is enough for the present to warrant us in assigning the ephyra and the scyphostoma to the same *morph*, thereby intimating that neither the elaboration of the one nor of the other necessarily has any reference to the formation of a particular kind of organ, but simply indicates that this is the method by which the different *varieties* of the cephalic morph are developed and repeated antero-posteriorly along the longitudinal axis of the *individuum*.

§ 5. *The individuality of Pelagia and Lucernariæ.*

24. The Pelagia which we have mentioned (20) retains its individuality in almost the strictest sense of which we have any example, in fact only the less so than in the highest vertebrates, because its dorso-ventrally repetitive element is less differentiated and more multiplied in its results.

25. The case of the Pelagia of Krohn brings us now directly to the consideration of the individuality of Lucernariæ. These cœnotypic forms of Acalephæ are only less individualized than Pelagia, because two varieties of one morph, viz., the hydroid and the medusoid, inseparably interfused, are patent to our senses in the same unit of form; memorizing, as it were, the separate condition of the hydroid and medusoid cephalisms among the lower, most indeterminately repetitive Hydromedusæ.

26. A Lucernarian might be compared with a scyphostoma which, instead of developing the anterior segment into the most usual form, with its numerous, long, slender tentacles, has evolved from itself another variety of the same morph, a

medusoid, in fact a *Charybdean*, which remains a permanent part of the body, whilst the region posterior to that has become differentiated to the highest degree of which the scyphostomic morph is capable. The medusoid cephalism is persistent, it remains to perform, in addition to its usual functions, a part which is most commonly assigned to the hydroid: thereby illustrating, by a whole order of beings, the theory that not only the hydroid cephalism, but the *most highly developed medusoid cephalism*, normally, may remain a constant part of what is commonly called a polypidom.

27. Seen in this light, the Pelagia already mentioned was a free polypidom with a single cephalic *medusoid* member, and the Lizzia, which Claparède[1] saw develop directly from the egg, was also a free medusoid polypidom; but probably not a single cephalic member, because the same species, we believe, has been seen to bud medusoids like itself from the sides of the *manubrium*. If this be true, then the Lizzia in question was a free, polycephalic *medusoid* polypidom for a certain period, in the same sense that Hydra is periodically a free, polycephalic, but dimorphous, Hydromedusoid polypidom. A polypidom, so-called, may therefore consist either altogether of a single variety of a morph, for instance, of all medusoids (Lizzia), or of two varieties, *i. e.*, of medusoid and hydroid, indiscriminately mixed (Hydra, Coryne, etc.), or systematically disposed in their relations (Sertulariæ, Tubulariæ), or the two varieties, the hydroid and the medusoid, may be merged into one, and that one may be represented by a single cephalism, a *unit*, as in Lucernariæ.

28. Why a Charybdean is selected above, for comparison, rather than an Aurelia or Cyanea may be learned in detail in the chapter (Part XI) upon the morphology of Charybdeidæ; suffice it to say, here, that they cannot be specially homologized, neither with the strobiloid Acalephæ nor with the Hydromedusæ, and that they can be so compared with the Lucernariæ.

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[1] Claparède, "Ueber geschlecht. Zeug. von Quallen durch Quallen," Zeitsch. für Wiss. Zoöl. 1860, vol. x, p. 401, Taf. xxxi, figs. 1, 2, 3.

PART II.

ANATOMY AND PHYSIOLOGY OF HALICLYSTUS AURICULA.

CHAPTER IV.

GENERAL FORM AND STRUCTURE.

§ 6. *Habitat, Habits, Form, and Size.*

29. *Form and Proportions* (Pl. I *figs.* 1–17).—In some of the attitudes (*fig.* 1) of this species, the form of the body, as a whole, might be compared to a lady's parasolette heavily tasselled at eight about equally distant points around the edge. The handle, then, would correspond to the thick, short peduncle at the caudal end of the body, and the ferrule-bearing tip would represent the proboscis. Imagine the parasolette turned inside out so that the usually concave under side becomes convex, and it would then have the shape which our Lucernarian most frequently assumes (*figs.* 4–7). It might, then, also be sometimes compared (*fig.* 5) to a broad, shallow, eight-sided fruit dish supported by a pedicel.

30. *Size.*—Keeping up the simile to the parasolette, or umbella, we proceed to indicate the size and proportions of this umbelliform mass. Full-grown specimens measure one inch (*figs.* 2, 3) across the umbel, or sometimes a little more, especially those collected at the latter end of the breeding season in our more northen, colder seasons. Including the tassellated tentacles the whole is equal to one and a half inches from side to side. The peduncular, caudal portion is at least one-half an inch long, and about one-twelfth of an inch thick, on the average, but, expanding rather abruptly at the extreme posterior end, into a truncate, discoidal, adherent termination, it is there a little more than one-eighth of an inch. The proboscis is the least conspicuous subdivision of the body, on account of its position and transparency; and, as it is extremely sensitive to the touch and highly contractile and extensible, its proportions can be made out only approximately, and therefore we can but say, in general terms, that it is about one-eighth, or from one-eighth to one-sixth of an inch long, or from one-fourth to one-third the length of the peduncle, and about as broad, in the average, as long. From these measurements, one would judge that the animal before us is, on the whole, rather stout and heavy in its proportions; certainly it is not slender, nor even approximately so, although it has a pretty wide range of general extensibility, and in some of its attitudes appears to be considerably elongated (*fig.* 7), but in the latter case this is more seeming than real.

31. *The interior configuration* (Pl. III, *fig.* 37) corresponds, in a general sense, with that of the exterior. The proboscis (ρ) forms the boundary of a similarly shaped space, and thence the passage is direct into a very wide quadripartite area (ω^1) which is coextensive with the depth and width of the umbella. The umbellar area (ω^1) narrows posteriorly into a broadly conical outline (ω^6), and then opens into four circumaxial, elongate, tunnel-like passages (τ^3), which extend to the posterior end of the caudal region. Essentially, therefore, the whole internal cavity constitutes one common chamber, which is subdivided in accordance with the configuration of the three principal regions of the body.

32. *Habitat.*—Although a free, single, independent body, *Haliclystus auricula* is eminently sedentary in its habits, and even is partially encased in a very short *sheath* at its posterior attachment, so that it has the appearance of being a permanently adherent hydroid, like Corymorpha, Hybocodon, etc., and in fact it is very rare to find it disengaged from its caudal mooring, when in its natural habitat. When, however, it is transported, with the eel-grass to which it is most commonly attached, it very often loosens its hold, slips out of its sheath, and moves about from place to place in its temporary abode As it is very difficult to keep it in a healthy condition, requiring a large amount of water, frequently to be renewed moreover, its habits, attitudes, configuration, and even general structure need to be observed as soon as possible after it is removed from its natural resting place, and if practicable, as we have often found it, even before this is done. The numerous figures (*figs.* 1–16) which we have placed on the plate (Pl. I) were drawn from life while the subjects were under the most favorable conditions, and are, therefore, fair samples of the natural attitudes and habits of this species.

33. As we have said above, it is most frequently found attached by its caudal extremity either to eel-grass (*Zostera*), or to the common *Fucus vesiculosus*, and very rarely to the solid rock. It would seem to prefer for its base of operations some object which is kept in constant motion by the action of the water, something which will assist it in coming in contact with the greatest possible amount of respiratory material. Hence we may account for the difficulty of keeping the animal in a healthy state in confinement. It will appear, to the inexperienced eye, to be perfectly well and fully expanded for three, four, or five days after capture, but during all this time it is quietly exfoliating its epidermis, both externally and internally, and finally indicates its illness, in its extreme, by falling from its attachment, and lying inactive at the bottom of the aquarium, contracted and rolled up into an almost shapeless mass. Such has been our experience whenever we ceased from making the utmost efforts to keep the animal supplied with an abundance of perfectly fresh and cool water. We have seen statements that it thrives well in an aquarium; but we are fully persuaded that it was only apparently so, and that, after the first forty-eight hours of confinement, it was unfit for anatomical investigation, certainly of a histological character.

34. *Attitudes.*—The principal attitudes of the body may be reduced to two in number; the one most common is when the umbelliform portion is more or less concave anteriorly (*fig.* 5), so that the proboscis is, as it were, surrounded by a very

broad excavation; and the other is when the umbel is thrown backward in such a way that its posterior face is concave (*fig.* 1) and the proboscis projects conspicuously from its convex anterior face. At times the umbel is arched so strongly forward that the body has the form of a wide-mouthed trumpet (*fig.* 4), or still more projected and narrowed it simulates the outline of a deep funnel (*fig.* 7). Yet near these two extremes of concavity and convexity of the front face there are all possible means, as may be seen by consulting the several figures which adorn the plate, representing this species at various ages. The highest degree of contractility of which it is capable is exhibited by inrolling the edge of the umbel so as to conceal the bunches of tentacles (*fig.* 15) and compacting itself into a globose mass, but without retracting the caudal cylindrical portion more than enough to give it a very broad columnar proportion (*fig.* 14), and never so much as to merge it into the general mass.

35. *Locomotion.*—The flexibility as well as the muscularity of the body is most vividly presented when the animal is roving from place to place. It has been said by continental observers that it swims like a pelagic medusoid, by alternately contracting and expanding its umbel; but although we have waded time and again for hours among the eel-grass where they were so numerous as to almost swarm, we have never once witnessed anything that could be compared to the pulsating movement of the umbella of a genuine oceanic Acaleph. It is true that we have seen these creatures detach themselves from their point of support, but they exhibited no systematically concerted motions which would drive them in any particular direction, and the whole process consisted in rapidly flexing or jerking the body from one side to another, with an occasional rapid folding together and unfolding of the opposite halves of the umbel. It is possible that the swimming faculty belongs to the *H. octoradiata* (*L. octoradiata*, Sars, *non* Lamarck), which has been so often and so long confounded with the species now under consideration. The usual mode of locomotion is by a process of creeping or stalking over bodies, after the manner of a Hydra, using as prehensible, or rather adherent, organs, the discoid caudal termination and the eight oval, kidney-like bodies (anchors, colletocystophores, § 104) which spring from the edge of the umbel, one by one, in the intervals between the clumps of tentacles. Rarely does this Lucernarian appear to use the tentacles as instruments of reptation, nor do they contain the adhesive bodies which make up so largely the mass of the kidney-like organs and the disciform truncation of the caudal end of the body. As the animal passes from point to point, it swings itself backward and forward, at one moment barely adherent by the edge of the caudal disk, and at the next, with an abrupt jerk, it throws the margin of the umbel against some object and tilts over, using one or two marginal bodies as *anchors* whilst it detaches the former base of support (*fig.* 13). In the latter condition it shows at times a high muscular power, by swimming abruptly from side to side, or with violent jerks and a sort of gyrating motion it throws itself into rapidly succeeding and varied positions, the heavy caudal region meanwhile whirling about in the watery space like a club in the hand of a gymnast.

36. *Color.*—The divers tints of the body range very widely, from a dark purple to an almost glassy green, and, even in the brownish colors, are always lighted up by a sort of opalescent play of varied intensity. Locality does not seem to have any influence here, for totally different hues are represented, side by side, in the same tide pool, and even upon the same blade of eel-grass. In any case the body is uniformly of one color, either all blue, or green, or olive, or yellow, or orange, very rarely red, but occasionally pink or violet, and from that it ranges in different individuals to a dark purple, or purplish brown. In very rare instances the color varies in different parts of the body.

§ 7. *The Proboscis.* (Pl. I, *figs.* 1, 2, 3; Pl. II, *fig.* 22; Pl. III, *fig.* 37; Pl. IV, *fig.* 50.)

37. The proboscis is not only typically, but actually, topographically, the anterior division, the foremost of the cephalic members of the body. In neither sense, though, is it distinctly separable from the umbellar region; the latter and the former insensibly shade off into each other, and, as it were, mutually overlap at alternate points. Generally speaking, the proboscis is quadrilateral from two different points of view (*figs.* 1, 2, 3, and 37 ρ), and so nearly alike in length and breadth that it has the contour of a cube, or of a very short quadrangular prism, the corners of which lie, respectively, two in the vertical axial plane of the body, and two, at ninety degrees from these, in the horizontal axial plane. The four sides of this organ, therefore, face obliquely at forty-five degrees from either of these planes. Viewed from the front (*figs.* 2, 3, 22), as the animal rests in the conventionally homological position for comparison, the proboscis presents a cruciate appearance, the angles forming the four extremities of the cross, thus +, the perpendicular arms of the cross corresponding to the vertical axial plane, and the horizontal limbs to the horizontal axial plane. Such are the outlines of this organ, in the main, but we must now particularize the several features, one by one, in order to complete the details of our topographical sketch.

38. The mouth is bordered by the four terminal smooth edges of the right and left sides of the proboscis (*fig.* 22 ρ); it is, therefore, quadrilateral also, but is modified more or less by the longitudinal plications and inarchings of these edges, so that, with varying degrees, it presents, from time to time, all of the intervening outlines between a rectilinear quadrilateral and a spherical quadrilateral. It is, moreover, altered in shape by the replication or rolling outward of the edges (*fig.* 1), or by their mutual approximation. There is no demarcation between the buccal orifice and the buccal cavity which is included between the four flanks of the proboscis; nor is the latter space separated by any intervening object from the post-buccal (ψ^6) or central umbellar chamber, which lies immediately behind it; the two latter insensibly run into each other, in the same way that the external contours of the proboscis and the umbel mutually blend.

39. *The basal region of the proboscis* is by far the most remarkable part of that organ, and is so singularly constructed that it would be impossible to describe it apart from the anterior umbellar floor, with which it forms a direct continuation.

It will on this account be more readily understood if we indicate, with a few light touches, the configuration of the anterior face of the umbel. This face is subdivided into eight alternately sunken and elevated regions, so placed that the sunken areas (*figs.* 22, 37, ζ^2) abut against the four sides of the proboscis, and the elevated fields are continuous with the corners (ζ^1) of the latter. The sides of the proboscis, it will be seen now, extend much further backward than the buttress-like corners; the former trending parallelwise with the axis of the body until they reach the uttermost depths of the umbellar concavity (at ρ^3, *fig.* 37), gradually narrow as they approach the bottom of the U-shaped sunken areas, and meanwhile insensibly shade off, laterally, into the gradually and consentaneously widening proboscidial buttresses (ζ^1); while the latter rapidly rise from the adjacent hollows, and shade off with a very gentle slant into the corresponding elevated regions of the umbel. The latter regions, therefore, lie, respectively, two in the horizontal axial plane, and two in the vertical plane, while the sunken areas trend each at an angle of forty-five degrees to these planes.

40. The flat sides of the proboscis do not by any means always stretch with a straight, smooth surface in a direct line away from the mouth, but rather, and most frequently, they are transversely wrinkled, and often deeply folded in the same direction; and to such an extent, sometimes, do these folds reach that they cover over a considerable portion of the deeper, proximal ends of the sunken areas, and form thereby a sort of *marsupium* or pouch (*fig.* 22, ζ^2). These folds evidently possess a high degree of contractility and expansibility, as they may either be extended so as to reach at least half way to the margin of the umbel, or they may be so retracted that the sides of the proboscis are perfectly smooth, as may be seen on its upper right side in *fig.* 22. The extensibility as well as the strength of the proboscis may be observed also when it seizes and swallows a shrimp of comparatively large size. The marginal adherent organs (a) are on such occasions of eminent service, while the tentacles are occupied in thrusting the victim into the widely spread mouth, whence it passes through the proboscis, which fulfils merely the office of a throat, to the general cavity.

§ 8. *The Umbella.* (Pl. I, *figs.* 2, 3, 17; Pl. II, *fig.* 22; Pl. III, *fig.* 37; Pl. IV, *fig.* 47; Pl. VI, *figs.* 61, 62, 66.)

41. *The Umbella.*—We shall next consider the form, proportion, appendages, contents, and general and special morphological relations of the middle division of the body. The umbella presents an outline which varies to a considerable extent with the shifting moods and attitudes of the animal. In profile it is concave in front and convex behind (*figs.* 17, 37), the concavity holding the proboscis in the middle, and the convexity abruptly narrowing off at its axis, into the peduncular, caudal termination (τ). Viewed from the front (*figs.* 2, 3, 22), it presents an octolateral outline, with eight strongly projecting corners. Of these eight sides four alternate ones are usually shorter than the others, and they are those which lie directly opposite the four flanks of the proboscis (*figs.* 2, 22, 37). Frequently, however, the proportions are reversed and the longer four become the shorter ones

(*fig.* 3), or they are all alike. The first case, though, is the one which is most generally met with, and sometimes the shorter sides are so strongly contracted and narrowed that the umbel has rather the appearance of a quadrilateral with four double corners (*fig.* 22), or the corners project so far as to have rather the appearance of arms (*fig.* 17). These sides are always more or less inarched, and with such a uniform curvature that the middle of each broad sinus is the point nearest to the proboscis, and consequently the borders of the same are most distant, and combine to form the corners of the octolateral.

42. *Umbellar Appendages.*—A very strong emphasis is put upon these alternating corners and sinuses by the appendages which project from their edges. The corners are rendered apparently more prominent by the implanting thereon of a thick group of cylindrical, globe-tipped tentacles (*figs.* 1–17, 22, 37, ϕ), whilst the comparatively inconspicuous edge of each interval is intensified by the addition of a dark, oval, kidney-shaped adherent organ (α). The manner of attachment of these bodies will be described under their respective headings, as we do not wish here to complicate the subject any more than is necessary to render the relation of the various parts of the umbel sufficiently clear for a perfect understanding of topography and morphology. The adherent organs (anchors) from their position in the sinuses, form a marked feature in the subdivision of the octagon, inasmuch as they lie severally, either opposite the flat sides of the proboscis or exactly confronting its four corners, and, therefore, have a closer and more direct relation to the planes of bilaterality and dorso-ventrality than the tentacles possess, which, as it were, stand obliquely to these, at regularly alternating points.

43. *The longitudinal diameter of the umbella, i. e.*, the distance from the anterior to the posterior face, is quite diverse at different points, but not without system. We have already anticipated this by inference, in the description of the basal prolongations of the proboscis (39). Conjoined with the four proboscidal buttresses (ζ), the four equidistant regions which lie opposite the angles of the proboscis have a far greater antero-posterior extension from the front to the back face than any other portion of the umbel, whilst the middle of the four subdivisions, which abut against the flat sides of the proboscis, measures the least in this respect. The reason for this will be apparent enough without going into details, upon stating that the middle of each of the four sunken areas (39) corresponds to the line along which the walls of the anterior and posterior faces of the umbel are united. These lines of junction—internal partitions (ψ^2), as will be learned hereafter (47)—may be recognized from without as four narrow, light bands trending, severally, from each of the four sides of the proboscis almost to the margin of the umbel.[1] Consequent upon this it is plain that the antero-posterior faces are further apart at one intervening point than at the partitions,

[1] One of the most elegant and characteristic figures of this species thus far published (see A. Agassiz's Illustrated Catalogue of the Museum of Comparative Zoölogy, No. II., North American Acalephæ, Cambridge, Mass., 1865, p. 63, *fig.* 88) is unfortunately marred by a serious morphological mistake in the drawing, by which the *angles* of the proboscis are made to appear as if lying opposite the partitions of the umbella and consequently facing toward the four double reproductive organs, instead of toward four points intermediate between these.

and most distant opposite the corners of the proboscis, since the areas continuous with the buttresses are the least depressed (39). From the latter points the faces in question approximate each other along two diverse lines, one trending in the direction of the partitions, where they are conjoined, and the other running to the margin of the umbel, at which place they combine to form a common border.

44. *The physiognomy* of the anterior face of the umbel is still further affected by the location of the subdivisions of the muscular system. This system is much more intensified and conspicuous in the regions adjacent to the partitions (ψ^2) than in the intervening areas, but in both localities it may be recognized by numerous ribbon-like bands (*m*) which extend parallelwise from about the base of the proboscis to the periphery of the umbel. The subdivisions are divided into two sets, of which there are four more prominent subdivisions opposite the flanks of the proboscis, and four others regularly alternating with these and running directly from the buttresses (ζ^1) of the same organ. These eight subdivisions are not apparently in contact with each other, but seem to be separated by the intervention of eight other subdivisions of another system of organs. The latter, the *genitalia*, are dark, triangular, flat masses (λ), which present the appearance of a pavement-work as seen through the walls, and extend, one by one, from the sides of the buttresses to the tentaculiferous corners (ψ^4) of the octagon. The absence of the muscular system over these triangular areas is only apparent, and is obscured by the darkness of the underlying mass. Finally there is a narrow ribbon (m^1) of muscle which borders the front face of the umbella, but does not extend as a distinct band over the corners where the tentacles are situated. By the action of the muscles the front face of the umbel is largely modified at times, either by the contraction of the fainter, weaker set, in such a way that the whole area opposite each of the buttresses, with the latter included, is thrown forward into a strong narrow ridge, and the adjacent triangular masses of pavement-work are approximated so as to touch, or even overlap each other (*fig.* 3), or at other times the stronger muscles narrow the sunken areas in which they lie, until they become quite restricted in extent and deeper as a whole in an antero-posterior direction, and simultaneously the intertentacular margin is shortened and rendered more deeply sinuous (*fig.* 22). On the whole it may be said that the entire floor of this face is quite thin and highly expansible and contractile.

45. *The posterior face* (*figs.* 17 and 66) of the umbella is quite simple in configuration. Being coincident at its margin with that of the front face, it is bordered by the same appendages, *i. e.*, tentacles and adherent organs, and by its semi-transparency allows a tolerably clear view of the partitions (ψ^2) and the dark triangular bodies (λ). Its thickness is very marked in contrast with that of the anterior face, nor does it ever appear to become wrinkled or folded to any distinctly appreciable extent. This may be readily accounted for, since we know that the bulk of it consists of a highly resilient, gelatiniform substance, continuous with that in the peduncle (58). Contrasted, then, with the other face, it might well be described as rigid. Opposite the four partitions, however, it is more or less slightly impressed with a shallow, broad, longitudinal furrow, which scarcely attracts attention unless looked for. That it is capable of being compressed or bent is

evident by seeing its margin follow all the various shapes which are assumed by that of the front face, but unless so affected it does not appear ever to change its contour. As we shall see hereafter, in detail, it has no muscular component, but is simply resilient when bent or compressed. In this respect its junction with the front face is very abrupt, but in point of configuration is comparatively gradual, forming with the other a smooth rounded edge (*figs.* 61, 62).

46. Since the three main subdivisions of the body have a close relation to the disposition of the various members of the organization, one would be justified, upon these premises, in looking for something marked at the point of transition from the umbella to the peduncular, caudal regions (τ). This presumption, however, is not warranted so far as the exterior surface is concerned, for we find there a very gradual transition in point of external features, but a rather abrupt change of general form. We must look within for more evident diversities between these two regions. There is no visible, structural dividing line which separates them, as there is between the front and the posterior faces of the umbella, and therefore it is not possible to say where the one begins and the other ends; the most that we can state is that the bulk of the posterior umbellar face is convex, but that behind this it rapidly curves off into a more or less broad, conical form, and then insensibly makes a transition into the peduncle.

47. *The interior of the umbella* next demands our attention. In regard to its general configuration it might with propriety be described as the mould of that of the exterior. We have already (43) indicated its subdivision into four compartments, when referring to the four partitions which unite the anterior and posterior faces of this region, but we have further details to add here, and shall therefore begin with the partitions as the foundation for the principal modifications of the general cavity of this part of the body. The anterior (*figs.* 22, 37, 66, ζ) and posterior (β) parietes of the umbella are united by their interior faces at four equidistant points, or rather lines (ψ^2), which from without have the deceptive appearance of tubes, on account of their comparative transparency. These extremely elongate areas of attachment, or of mutual fusion, extend from each of the bases of the four flat sides of the proboscis to within a short distance of the margin of the umbella, and then abruptly terminate. Consequently at each of these four points of termination there is left a passage-way (ψ^7) from one compartment to the other, and therefore the subdivisions of the general cavity intercommunicate at their distal ends, as well as at the proximal apertures behind the base of the proboscis.

48. *These partitions* can scarcely be called division walls, as they have barely an appreciable depth, but are rather to be compared to low ridges on two opposing surfaces which have inosculated along their crests. By making a transverse section (*fig.* 61) across two approximated arm-like angles of the octagon, the slight depth of the partitions (ψ^2) can be very clearly demonstrated. We should not fail here to state their exact topographical relations, since they constitute an important element in the morphological construction of the body, both as regards its ordinal characters, and in the consideration of its embodiment of the typical idea of the grand division to which it belongs. The vertical and horizontal axial planes being understood to lie in continuation of the four diagonally opposite corners of the

proboscis, it will be seen that the partitions must be inclined at an angle of forty-five degrees to these planes, since they trend perpendicularly from the middle of each flank of this proboscis toward the umbellar sinus which lies nearest to and opposite said flank; and, moreover, it follows that the midline of each of the four compartments of the general cavity is coincident with either the one or the other of these planes. The lateral extent of these compartments is limited only by the narrow partitions, but that is enough to define exactly their relation to the angles of the proboscis, the butresses (ζ^1) of the latter projecting in strong ridges over the middle of the compartments, and in fact forming, in part, the front wall of their proximal ends. Thus it is evident that the general cavity (ψ^1) cannot be separated by any demarcation from the post-buccal chambers (ψ^6). The peripheral extent of this chamber is limited only by the conjunction of the anterior and posterior parietes of the umbella, and it even is prolonged into the tentacles and adherent organs, both the latter and the former being hollow to their tips.

49. *The organs* which are included in these compartments belong to but one system—the *reproductive.* They have already been mentioned (44) as dark, triangular pavement-like bodies; but their exact relation to the walls of the umbella has not been stated, and therefore one of the most important morphological features of the whole animal remains to be delineated. That they are totally within the cavity embraced by the front and back faces of the umbella, and that they have no communication with the exterior except through that cavity, might be sufficient to affirm before the time of certain recent discoveries in regard to the relative position of the reproductive organs, or of the region of the reproductive process, but at present it is absolutely indispensable that one should enter into the utmost topographical *minutiæ.* We shall not here, however, proceed to the ultimate details of these organs, but merely place them in the proper light as far as their *site* is concerned, and leave the rest to be worked out in the chapter (V) on the anatomy of the various organs with which the body is diversified.

50. *The reproductive organs* (λ–λ^5) would appear, without much consideration, to be as many as there are corners to the octagon which incloses them; but we are assured, for reasons which shall not be entered into here, but may be found in the chapters on their anatomy (V) and on ordinal characters (XIII), that there are only four subdivisions of this system, but that each part is two-fold. The whole system is adherent to the inner surface of the anterior wall, circumoral area, (ζ) of the umbella, and, from its proximo-distal extent, lies in almost the closest possible contiguity to the proboscis. Each half of the four subdivisions corresponds to one of the dark, triangular, pavement-like bodies already referred to (44). The triangle (*figs.* 22, 37, λ^1, λ^2, λ^3) is broadly obtuse, and its longest, basal side (λ^3) stretches in a slightly curved line, and at a very sharp angle to the neighboring partition, from a point close to the bases of the tentacles, two-thirds, or even three-quarters, of the distance (λ^4 to λ^5) to the axis of the body. Of the two other sides, one is shorter (λ^2) than the other (λ^1), and lies nearer the proboscis. They are both more or less outwardly arched, and by their conjunction sometimes appear to form parts of a continuous curve rather than a very obtuse angle. Each partition (ψ^2) lies midway between the two triangular

halves of an organ, and consequently, it seems plain enough that the halves of adjoining genitalia occupy the same umbellar compartment; or, from another point of view, the halves of the same genitalia are to be found in two different, but juxtaposed compartments of the general cavity. The longest side (λ^3) of each triangle faces its mate, and the two have a partition stretching between them equally distant from either.

51. In a former paper[1] upon this animal we have already drawn attention to the high specialization of these organs when contrasted with those of all the other Acalephæ, and we wish here to emphasize still more strongly the idea which was there set forth for the first time. It has been noticed that these triangular halves are compounded of irregularly rounded bodies so closely set together as to appear like a pavement-work (44). These are nothing less than spherical sacs (*figs.* 37, 61, 62, *s*), attached one by one, and by a short neck, to the inner face of the floor; and within these only are to be found the eggs or spermatic material, according as the animal is male or female. It will be noticed, also, that the largest sacs are in the region of the obtuse angle of each triangle, and that they gradually diminish in size as they approach the basal side (λ^3) and the distal (λ^4) and proximal (λ^5) acute angles. Here, again, are two other eminent features of differentiation, and of a degree such as is not equalled in the whole class of Acalephæ; in fact it would seem as if we ought to consider each globular sac as a separate organ, and regard the triangular bodies as merely the expressions of the mode of grouping of the organs. At any rate, the suggestion will serve to heighten the sharpness of the features of differentiation so remarkably worked out here, and may perform the same office in estimating the quality of the same process in other creatures of this class. Nevertheless, we shall at least insist that every organ is composed of two of the triangular groups of spherules, and in this assumption we are supported by other evidence than that already adduced.

52. *The digitiform bodies* (γ), which appear in such large numbers near the base of the proboscis, are arranged with special reference to the divisions of each reproductive organ, and form the connective which gives unity of configuration to the genital halves. They are disposed quite regularly in three or four rows, which lie close together and extend from the proximal end of a partition in a direct line to each of the halves, and then border the shortest side (*fig.* 22, λ^2) of these triangles for about one-third of their length. We have, then, four groups of digitiform bodies, so appended to the genitalia that they appear not only to hem in the two parts of each organ, but also to stand as a barrier against communication between any two halves which lie in the same umbellar compartment. We do not pretend to say that they are functionally connected with the genitalia, but merely describe them thus from a topographical point of view. These are extremely flexible, plastic, and muscular bodies, and vary in shape from broad lanceolate, when they are contracted, to linear lanceolate, when extended to their full length. They are very active, constantly in motion, and no doubt serve

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[1] Lucernaria the Cœnotype of Acalephæ. Proc. Boston Soc. Nat. Hist., March 19, 1862, and American Journ. Science, May, 1863.

both as organs of prehension and adhesion, since they are covered on one of the opposite flattened sides with urticating organs and vibratile cilia, and on the other with adherent vesicles (see § 15). With such an array of grappling apparatus, crowded about the post-buccal cavity, and with the fact in view that these bodies are seen to project out of the mouth at times, there cannot be much doubt that they are eminently efficient in capturing and drawing the prey within the folds of the body, and into the general cavity.

53. *The posterior division* (ψ^6) of the main cavity lies altogether behind the entrance to the four lateral compartments, and is embraced within the broad conical termination of the umbella. Its outlines correspond almost exactly with the exterior configuration of the wall which contains it. Anteriorly it is directly continuous with the buccal cavity, and diverges in four different directions, right and left, and with very wide passages, into the four umbellar compartments (*fig.* 37, ψ^1). Posteriorly it is rounded off, and opens (*figs.* 37, 50, τ^4) directly and abruptly into the four, circumaxial, longitudinal channels (τ^3) of the peduncle. At four equidistant points in its lateral periphery there are as many longitudinal low ridges, which trend in a direct line from each of the partitions of the umbella backward, and gradually thin out and disappear a short distance in front of the apertures of the canals of the pedicel. They are composed, in the main, of fibres (r^2), which may be traced, anteriorly, into the flabelliform muscles which constitute a part of, and lie on each side of, the partitions, and posteriorly they plunge into the solid mass of the peduncle and run (r) to its extreme posterior end, keeping strictly in the middle of the spaces which intervene between the longitudinal canals (τ^3).

§ 9. *The Peduncle.* (Pl. I, *fig.* 17; Pl. II, *figs.* 18, 19; Pl. III, *fig.* 37; Pl. IV, *figs.* 47*, 50, 51; Pl. V, *fig.* 52; Pl. VI, *fig.* 66 τ–τ^6.)

54. *The peduncle* is unquestionably the preëminent feature of interest in considering the morphological relationships of this peculiar order. It is that which, added to the umbellar division of the body, caps the climax of the process which is at work reducing the diffuse medusoid and hydroid cephalisms of the lower groups to more intimate alliances in the higher families, and finally combining them in a single unit of form, the *hydra-medusa individuum*, Lucernaria. The complicated organization of the peduncle—the hydra element of our cœnotype—surpasses that of any hydra (scyphostoma included) thus far met with. The mode of junction with the umbella has already (46) been described in reference to the latter. The precise point is not observable on the outside, but the transparency of the wall allows the interior to be seen with full clearness, and in fact the organs there are so conspicuous as to blend in the vision of the exterior. By this we learn that the apertures (τ^4) of the peduncular canals (τ^3) are on a line with the spot where the posterior, conical termination of the umbella fades into the cylindrical shaft of the peduncle. From this point the caudal subdivision of the body retains its circular form in general outline, but is subdivided lengthwise by four furrows (*figs.* 52, 66 τ^6), which extend to the posterior truncate termination, and even over the

adherent face of the latter, and meet exactly in the axial line of the body (*fig.* 18 γ^1). The shaft, then, is slightly four-lobed in a transverse section (*fig.* 52), the dividing furrows (τ^6) running as if in continuation of the four slight, broad furrows which overlie the partitions in the umbella (45), and therefore standing in the same relation to the vertical and horizontal planes of the longitudinal axis. In the peduncle the furrows overlie the four muscular cords (r) which intervene between the longitudinal canals (τ^3). The sides of this shaft run nearly parallel to the axis, diverging but slightly, when the animal is fully expanded, except at the posterior terminus, where they spread abruptly to form a disk-like, truncate expansion (*figs.* 17, 37, 66 γ). This disk is four-lobed by the indentation of the longitudinal furrows, and its posterior face is not only divided into four equal areas by these furrows (*fig.* 18 γ), but is traversed in every direction by minor furrows, which form a sort of network. The obvious office of the disk is that of an adherent organ, and to that its minuter structure corresponds, since we find in its broad, transverse face a multitude of adherent vesicles (see §§ 14 and 28), identical with those which are imbedded in the surface of the marginal bodies (§§ 13 and 27) of the umbella. The general surface of the peduncle is slightly undulating when fully extended, but upon contraction it becomes quite strongly corrugated, and principally in a transverse direction. Under all conditions, whether of extension, expansion, or contraction, its disciform posterior termination retains its peculiar physiognomy, not only in regard to form but in reference to its singularly areolated surface. The flexibility of the peduncle has been noticed in an earlier paragraph (35) on the mode of locomotion of this creature.

55. *The sheath*, which we have formerly mentioned (32), is so short and transparent, and so closely set to the surface of the pedicel, that it is scarcely noticeable. It covers but a short space, reaching from the edge of the adherent disk hardly more than an eighth of an inch forward. It has sufficient consistency to retain its shape in a great measure after the pedicel has been withdrawn, and, although it is nothing more than a filmy excretion, its presence adds largely to the stock of characters which stamp upon this region of the body the impress of the hydroid morph.

56. *The caudal interior* is much more expressive of the hydra-morph than the exterior, for here we may find special parallelisms in organization with that of the scyphostoma-form of the strobiloids, as described by us in subsequent pages (Part XI). The exterior, by its form and the adherence of its base-like terminus, lends greatly to its similitude to a hydra; but it is the interior which, by its evidently special, organized fitness to perform the functions of the hydra-morph, gives the strongest testimony in this case. We discover, in the first place, not a single open space in this region, but no less than four interior compartments (*fig.* 52), and they are what appear from the exterior, to the superficial observer, to be so many dark longitudinal cords (*figs.* 17, 66, τ^3), and which obscure, by their semiopacity, the true muscular cords (r) that lie intermediate to them.

57. These *caudal compartments* (τ^3), or longitudinal canals of the peduncle are nothing more than four diverticuli from the main cavity; but yet they stand in such peculiar, definite relations to the other main compartments, and with like

precise relations to the several members of the organization, that they are by no means to be touched upon slightly in this general sketch. They lie exactly in the same relation to the vertical and horizontal axial planes as do the four anterior umbellar compartments (*fig.* 37, ψ^1), and, as mentioned above (53), alternating with the four muscles (r) of the pedicel, which run continuously backward from, and in the same trend with, the partitions of the umbella (see *figs.* 37 and 50, ψ^2 to r^2). They are narrowest at their entrances (τ^4), and do not increase in diameter for a short distance, but soon they broaden rather abruptly, and then gradually widen as we follow them backwards until they reach the transverse wall of the disk-like, adherent organ (*figs.* 37, 51, γ), where they again broaden rapidly, and become continuous (τ^5) with one another through lateral channels, and occupy nearly the whole thickness of the peduncle. In a longitudinal section (*figs.* 37, 50, 51) their outlines appear quite ragged, and this irregularity seems to increase toward the posterior end, and finally the indentations become so deep as to meet (τ^5) each other between adjoining canals, and form thereby very tortuous inter-communications in the solid gelatiniform mass. Upon making a transverse section (*fig.* 52) of the peduncle, the outline of these canals has an ovate figure (τ^1), with the narrower ends nearest the axis of the body, and the broader next the periphery. The vertical and horizontal axial planes correspond, therefore, to the larger axis of these ovate figures. Their broader ends, that is the distal sides of the tubes, lie about as far from the surface of the pedicel as their narrower ends are from the axis, leaving about the latter a solid mass, which is between one-fourth and one-third the diameter of the whole caudal region. Between every two tubes there is a little more than twice as much space, filled by solid matter, as each one of them occupies. The dark color of these tubes is owing to the large opaque muscles of the cells of the lining wall.

58. *The solid gelatiniform mass* of the pedicel, which is mentioned above (57), is directly continuous with an identical substance (*fig.* 50, c^1 to c) which constitutes the bulk of the wall of the posterior face of the umbella, and gives to it that resilient consistency so characteristic of it when contrasted with the anterior face. It is easily recognized by its transversely striated appearance, and is about equally thick in the umbella and in the peduncle, where it abuts against the compartments of these two subdivisions of the body. At alternating points to these it is a solid mass over the entire diameter of the shaft, but is broken in continuity by the muscular cords (*fig.* 52, r), which are embedded in it. At the posterior end of the peduncle it is perforated (*fig.* 51, c^7) and much reduced in quantity by the anastomosing channels (τ^5), and is considerably thinner than in front at the transverse face of the adherent disk, and is, moreover, deeply pitted there by very irregular indentations which give the inner surface the appearance of a network (*fig.* 19, τ^3).

59. *The muscular cords* are the last objects which will occupy our attention here. From their peculiarities and high degree of development and differentiation, they present the most urgent claim for our consideration. They are by far the most eminently specialized muscular organs to be found in the whole class of Acalephæ. Their structure will not be entered into here, as it belongs to the

sections on organography (Ch. V), and we shall, therefore, confine ourselves to laying down their topographical status and their relations to the sites of the other organs. This we have in part anticipated when describing the caudal compartments, but considering the importance of their morphological features, we need not hesitate to repeat what we have said concerning the muscles, especially as the subject matter will be viewed from another stand-point. In the paragraph (53) upon the posterior division of the main cavity, four low longitudinal ridges were described as trending along its inner face and finally disappearing near its junction with the caudal channels. These ridges (*figs.* 37, 50, r^2) are the muscular cords, which, in this region, come to the surface as they pass forward from the pedicel into the umbella. In a transverse section of the peduncle it will be observed that they appear as triangular bodies (*fig.* 52, r) which lie nearer to the surface than to the axis, and exactly half-way between the canals. At the extreme posterior end of the peduncle they expand rather abruptly into a sort of truncate brush (*fig.* 37, r^1), and bending there, at a right angle, extend along the inner face of the adherent disk to the axial line, still buried, however, in the gelatiniform layer (*fig.* 19, r^1). Passing forward, each one keeps its place midway between the canals, and pretty near the exterior at first, but, at the anterior third of the peduncle, swerves from this course, and gradually approximates the axial line, and finally strikes the surface of the posterior division of the main cavity a short distance in front of the entrances to the peduncular channels. Here it is that they begin to rise above the level of the parietes of the cavity, and extend, with rapidly decreasing diameter, in the form of low ridges (*figs.* 37, 47^a, 50, r^2) (¶ 53), to the proximal ends of the partitions. At these four points each one enters a partition (ψ^2) and passes forward very obliquely (*fig.* 47^a, r^2 to ψ^5) toward the outer surface of the anterior or *circumoral* face of the umbella, and there expands into a thin stratum (m^4) just beneath the superficial layer of cells. These then are the only points where the muscular layer of the umbella (¶ 44) is united with that part of the system which is in the peduncle. It is at these points, also, that the muscular layer of the proboscis (*fig.* 47^a, m^6) is connected with the cords.

CHAPTER V.

ORGANOGRAPHY.

§ 10. *The Walls.*

60. *The nomenclature* of the various regions of an Acaleph is as yet in its infancy, and particularly so in regard to the strata of cells or of substances of other forms which constitute the solid parts of the body. Huxley and Allman[1] were the earliest

[1] See Huxley in Phil. Trans. Roy. Soc., 1849, and "*Oceanic Hydrozoa,*" in Roy. Soc. Pub., 1859. Also Allman, *Anat. Cordylophora,* Phil. Trans., 1853, and Report Brit. Assoc. for 1863.

advocates of a distinctive nomenclature for the Acalephæ. The former designated the walls of the body as the "*foundation membranes*," and the latter applied to the same, the distinctive names: *ectoderm* for the outer wall and *endoderm* for the inner wall of Hydroida. Later Allman added several other names to what he considered to be subdivisions of the ectoderm; but, as his views in regard to the relation and mode of development of the walls of a medusoid are so widely at variance with our own that we are wholly at a loss in the attempt to homologize the several parts of what we believe to be the typical medusa with those of Allman's type, we shall merely refer the reader to the section (Part XI) where these things are set forth in full detail, and proceed to describe the matter in hand with such terms as we may find most convenient and best adapted to our theory. These terms have been already, in part, promulgated in a note to an article[1] on the *non parthenogenesis* of Tubularia, and we shall add here a few more as the necessities of the case may demand. It will be understood at a glance that, since we apply this nomenclature to all of the Acalephæ—the Ctenophoræ being excluded, as we believe them to belong to a distinct class—we hold to the identity of the general conformation of the organs of every order included in this group. The minor details which serve to characterize each order and distinguish it from every other, may be, in part at least, indicated by the mode of using the nomenclature or by the introduction of such combinations of terms as will suit the ever-shifting exigencies of descriptive anatomy. For the sake of the convenience of reference, and a ready understanding of these terms, we have so constructed an *index* that it may be used as such, and at the same time for a *glossary*, by referring to the numbered paragraphs in the body of the memoir.

61. *The Opsophragma.* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 47*; Pl. V, *figs.* 53, 54, 60; Pl. VI, *figs.* 61, 62, 63, 64; Pl. VII, *figs.* 74, 77; Pl. VIII, *figs.* 85, 88, 90, 91, 93; *n* to n^3.)—What one would very naturally call the outer wall of the body (without any reference to its mode of formation, but simply because it covers the organization from its extreme anterior end to its posterior terminus), in reality embodies two distinct subdivisions; yet both of them lie upon the surface. One of these divisions extends from the mouth to the edge of the umbella, and the other from the latter point to the posterior end of the peduncle. The first of these corresponds to what we have, on a former occasion, designated as the *endophragma* of the medusa-form of the Hydroida, on account of its internal position, within the campanule, during the process of fissigemmation. Under present circumstances, however, we have deemed it best to introduce another term, of equally distinctive meaning, but having particular reference to our views in regard to the antero-posterior axis of the body—*opsophragma*, meaning the *face-wall*. It is confined strictly to the anterior division, or *front face*, of the umbella, and embraces within its folds the tentacles and the marginal adhesive corpuscles (*anchors*). It varies in thickness to a considerable degree, and passes from the *minimum* to the *maximum*

[1] "*Tubularia not Parthenogenous*," Am. Journ. Science, Jan. 1864, p. 65. "On the walls of the most highly developed medusoid."

in this respect, with no little abruptness, at some points on the periphery; but, notwithstanding this, it never presents more than *a single stratum of cells* (*figs.* 85–93) between its outer and inner surfaces. Consequently the varying thickness is due to a diversity in the depth of the cells, and not to a greater or lesser amount of these, superposed one upon another.

62. If we commence at the mouth (*fig.* 53, ρ^1) and trace this layer over the various subdivisions of the hydra-medusa, we shall meet with the following characteristics. At the edge of the lip (ρ^1) it (n^3) is continuous with the inner wall (i^7), and is very thin and epithelioid at all times, but varies with the amount of contraction or expansion of the proboscis (*manubrium*, Allman). From this point passing backward over the manubrium, and along its butresses to the umbella (n) and thence to the margin of the latter, we do not notice any marked change in the thickness of the wall until we approach the region of the tentacles and the anchors, but observe that it is here and there wrinkled, or compressed into tubercular or ridge-like thickenings by the action of the underlying muscular layer (m). At the margin intervening between the prehensile organs it passes directly into the wall (*figs.* 61, 62, f) (*ectophragma*) of the posterior face without any marked change, but at its transit to the tentacles and in particular to the anchors it becomes more massive. On the tentacles which lie most distally it scarcely thickens throughout their length, but where it becomes a part of their globose terminal expansions it increases in depth very abruptly (*figs.* 33, 54, ϕ^2), so as to form full two-thirds of the radial diameter of the spheroids. On the youngest tentacles (*fig.* 54, A, ϕ^2) it thickens quite rapidly until it reaches its maximum at their gradually expanding tips. Its passage over the anchors is signalized by quite variable changes in thickness. In the median furrow (*fig.* 47, n^2) it becomes only moderately thick, but almost abruptly so, while at the sides of these organs it rapidly deepens to four, five, and even six times its thickness on the face of the umbella, and finally thins out suddenly, on the distal side of the anchor, just as it makes a junction with the ectophragma (*fig.* 47, f).

63. *The ectophragma* (Pl. II, *fig.* 19; Pl. IV, *figs.* 46, 47, 47ᵃ, 51; Pl. V, *figs.* 52, 54, 60; Pl. VI, *figs.* 61, 62, 63, 64, f to f^2) is the true outer wall of the body, in a homological sense; although it seems here, upon casual observation, as we have limited it, to be only a part of the external envelope. Its homological limits, though, are bordered by the peripheral margin of the opsophragma on the front face of the umbella, and it is, therefore, restricted to the posterior face and its caudal prolongation, the so-called peduncle. Throughout this wide extent of length and breadth it is quite smooth and does not vary in thickness, and but little excels that of the *opsophragma*, until it enters the region which we have designated as the adherent disk (*figs.* 19, 46, 51, f^2) of the peduncle. There it rapidly attains to double or treble its previous depth, and becomes, at times, quite strongly corrugated as it follows the abrupt, sharp angles of the network of furrows; but still, like the opsophragma, it consists of only one stratum of cells.

64. *The opsomyoplax* (Pl. IV, *figs.* 47, 47ᵃ, 48; Pl. V, *figs.* 53, 60; Pl. VI, *figs.* 61–64; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 85, 90, 91, 93, m to m^6) is the stratum of muscular substance which immediately subtends the *opsophragma* (¶ 61),

or, in other words defining the meaning of the term, it is the *face muscular layer;* and to it are due all the numerous changes of physiognomy and attitude which the umbella of this creature exhibits from time to time. It has the same extent both anteriorly and posteriorly, and over the tentacles and anchors, as the wall which it underlies, but, unlike the latter, its borders terminate abruptly, without connection with any other stratum. Its continuation with the peduncular cords has already been described in a previous paragraph (59). The peripheral margin (*figs.* 61, 62, k^1) is not exactly coincident with that of the opsophragma, as it terminates at this place in a peculiar manner, which will be described hereafter in the section (§ 11) on the muscular system. As it is one of the layers which add to the bulk of the body and serve as partitions between other strata, it is desirable to mention certain features here which distinguish it from those on each side of it, or which serve to assist in defining the boundaries of adjacent strata. In general terms it may be said to be even thinner than the opsophragma, at its least depth, but, unlike that, it does not vary in thickness over considerable areas, and yet there are regions, quite limited it is true, within which it appears to attain a great thickness. But these are rather to be considered as deep folds (*figs.* 61, 62, m^1, m^1), and correspond in position to those places where the muscular system seems to be composed of parallel bands or cords (see ¶ 44). After what has been said above, it will hardly seem necessary to remark that it totally fails in the region of the *ectophragma* (¶ 63); but we must not omit to add that another part of the same system, in another form—the peduncular cords (¶ 59)—appears in that portion of the body, but, in this genus, does not form a distinct layer.

65. *The chondromyoplax* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 47^a, 48; Pl. V, *figs.* 53, 54, 60; Pl. VI, *figs.* 61-64; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 90, 91; Pl. IX, *figs.* 98, 100, b to b^s), or the *musculo-gelatiniform layer* as we have called it in another paper,[1] and the *chondrophys*, or the *gelatiniform layer*, constitute, together, by far the greater bulk of the solid material of the body. They are the jelly-like substance which renders the umbella of the medusiform Acaleph so massive. Among the Hydroida it is the *chondrophys* which forms the distinctive feature of the medusa-cephaloid, and the only thing which the hydrocephaloid variety of this morph has not, the *chondromyoplax* being altogether absent in neither (Part XI). Among the Strobiloida, the medusa-cephaloid possesses both of these layers, while its hydra-cephaloid—the *Scyphostoma*—has only the *chondromyoplax* (Part XI, *Aurelia*). The latter will here receive our first attention. The most notable feature, besides the thickness of the chondromyoplax and its excessive extensibility, flexibility, and compressibility, is the striation which traverses it from surface to surface; yet we do not pretend to say that by this the layer may be distinguished from all others, for a similar striation prevails in the chondrophys (¶ 69), but we claim that it alone, among the walls of the front parietes of the umbella, possesses this characteristic, and by means of it may be traced to its utmost limits with a comparatively low magnifying power. This layer underlies and is coextensive with the opsomyoplax (64), and in fact we cannot well persuade ourselves that it is altogether a separate *stratum* from the

[1] "Lucernaria the Cœnotype," etc., *ut sup.*

latter, the one seeming to bear the same relation to the other that the cells of some tissues do to the *cytoblastema* in which they are imbedded. We shall speak of this again in the section (§ 25) on histology, and consider it here as a distinct layer, on account of its large share in making up the bulk of this subdivision of the umbella.

66. At the edge of the lips of the *manubrium* (*fig.* 53, ρ^1) the chondromyoplax takes its rise with a sharp border (b^7), but rapidly thickens until a section of its diameter measures six or eight times that of the neighboring opsophragma (61). At the base of the proboscis it thins considerably (b), but with varying degrees, according to the direction in which we trace it. If we follow it along the proboscidial buttresses (*i. e.*, from the angles of the manubrium) passing between adjacent genitalia, directly to the border of the umbella, but a little to one side of the marginal corpuscle, we shall find that it preserves a tolerably uniform thickness until within a short distance of its periphery, and then it thickens again at a rapid rate and continues to do so (*figs.* 61, 62, b) until it terminates abruptly with a concavo-truncate edge, only separated from the equally abrupt terminal border of the chondrophys (c) by a thin fold (k^1) of the opsomyoplax (¶ 54). It is this fold, then, which is the peripheral terminus of the muscular layer of the umbella, and at the same time the intervening partition which prevents the chondromyoplax (b) from abutting directly against the convex edge of the chondrophys (c). Here is the dividing line between the two antero-posterior subdivisions of the umbella, and such, we shall learn, is the characteristic feature of it at all points of the periphery. If we trace the chondromyoplax from the buttresses directly to the anchors, it will be seen that it does not thicken so rapidly as before near the latter, and that it passes directly into them (*fig.* 47, b^2), as it cannot otherwise do, since these organs are nothing but saccular protrusions of the marginal portion of the anterior face of the umbella. The mode of termination at the distal side of the base of the anchors is the same as at all other points in the periphery. Within this saccule the chondromyoplax thickens rapidly as it enters, and attains to a greater depth by the time it reaches the muscular partition (k^1) which divides it from the chondrophys, and there ends abruptly (against k^1). Again, if we make a section of this layer along one of the genital halves from the proboscis to, and inclusive of, one of the bunches of tentacles (*fig.* 37), it does not appear to differ in point of thickness from the last section, but its course is varied by diverging at the digitiform bodies (*fig.* 98, b^4) and every genital saccule (*figs.* 74, 77, b^3), and penetrating them to form one of their strata; and finally, without any change, it passes onward and into the tentacles and becomes a component of no small proportions in those organs (*figs.* 90, 91, b^1). After traversing the intervals between the tentacles, diverging into the latter on the one side (*figs.* 54, 60, b^1), and into the intertentacular internal lobules (b^5) on the other, it terminates at the distal side of the tentacles (against k^1) in the same way as described in the other sections, but with a thickness less by one-half.

67. There are four places in the umbella at which the chondromyoplax comes into direct contact with the chondrophys, and these correspond to the four lines along which the anterior and posterior internal faces are united to form the parti-

tions (47, 48). The peculiar relations of this stratum are best displayed by two sections made at right angles to each other, the one (*figs.* 47, 47*, *b*) passing from the proboscis lengthwise along a partition, so as to split it, and the anchor which lies opposite to it, and the other cut traversing it crosswise (*figs.* 61, 63, *b*, *b'*) so as to show its breadth between the two adjoining umbellar cameræ. In the longitudinal section (*figs.* 47, 47*, *b*) it exhibits a pretty uniform thickness from the proximal to the distal end of the partitions; but is not so thin by one-half as at intermediate points, as the crosswise section (*figs.* 61, 63, *b'*) shows very conclusively; and it evidently constitutes almost all—a thickening (m^4) of the opsomyoplax along this line occupying the rest—of the depth and breadth of the partition, the chondrophys (c^4) which meets it, scarcely projecting beyond the level of the posterior inner surface of the adjacent cameræ. Just before it reaches the distal end of the partitions it begins to thicken, and finally that part which fills these partitions terminates abruptly (*fig.* 47, *b*) at the passage-ways (ψ^7) between the compartments of the main cavity, while its more anterior portion stretches onward into the anchors (b^2), and is there disposed and terminated in the same way as indicated when speaking of this layer in the four alternate anchors. At the proximal ends (*fig.* 47*, ψ^5) of the partitions it runs backward behind the base (ρ^3) of the proboscis a short distance, and forms a part of the four low ridges, which were described in a former paragraph (53) upon the posterior division of the main umbellar cavity, and thins out to nothing just at the point where the peduncular muscle (r^2), in passing forward to the anterior parietes of the umbella, strikes the lining wall (*i*) of this cavity. Here too the chondromyoplax is perforated, or rather, since it is scarcely wider than the muscular cord, is cut in two by it, as the latter penetrates to the front and joins the anterior subdivision of the muscular system—the *opsomyoplax* (m^4).

68. One of the most convenient methods of getting a general view of the varying thickness and irregularities of the chondromyoplax, is by taking advantage of the sometimes unusual elongation of the corners of the umbella, and making sections across them singly or across a pair of them, as we have done (*figs.* 61, 62). In the one across a single corner (*fig.* 62) we see that where the layer in question comes to the edge of the umbella it has a very abrupt, truncate-concave termination (*b*), fitting, with the intervening opsomyoplax (k^1), against the convex abrupt edge of the chondrophys (*c*), like a ball-and-socket joint. We notice, too, that near these edges it is deeply indented by folds (m^1) of the marginal muscle, and that the same phenomenon occurs over a narrow space close to the genital sacculus, where the muscular bands (m^4) are strongest and heaviest as they trend parallelwise to the partitions, in their course toward the periphery of the umbella. Its relation to the genital saccules, we have already (¶ 66) pointed out, and we will, therefore, proceed to consider the other section (*fig.* 61), which in this case includes one of the partitions (ψ^2). The marginal termination, and the relation of the chondromyoplax to the genital saccules is the same as in the previous sectional view, but between the saccules and the partition it differs in that the whole breadth of it is strongly indented by thick folds (*m*) of the opsomyoplax, and immediately opposite the partition this muscular layer (m^4) is so thick as to reach almost to the base level of the

partition, and is so strongly convoluted as to appear like the end of a bundle of threads cut across.

69. *The chondrophys* or chondrin-like layer (Pl. II, *fig.* 19; Pl. III, *fig.* 37; Pl. IV, *figs.* 46, 47, 47ª, 50, 51; Pl. V, *figs.* 52, 54, 58, 60; Pl. VI, *figs.* 61–64; Pl. VII, *figs.* 82, 83; Pl. X, *figs.* 127, 128; *b* to b^5) is restricted to the posterior parietes (*fig.* 37, β) of the umbella, and to the peduncle. Compared with the chondromyoplax (65–68) it is much more rigid, dense, and inflexible, quite resilient and elastic, and of a tough, jelly-like consistency. That it is dilatable and compressible is plain enough when the corners of the octagonal umbella are prolonged into conical arm-like projections, or when the peduncle shortens from half an inch to one-eighth of an inch in length, and then regains its first proportions. Like the chondromyoplax, it is nearly colorless, only slightly tinged with yellow or amber-color, and very transparent. It is faced on the front by the lining wall (*gastrophragma*, ¶ 75) of the main cavity, except at the partitions, where it meets the chondromyoplax, as was stated in a previous paragraph (67), and is covered on the opposite side by the outermost wall (*ectophragma*, ¶ 63) of the posterior parietes of the umbella. The massiveness and weight of this layer are unapproached by those of the chondromyoplax, and the only point at which the latter equals the former in thickness is at the margin of the umbella, but yet even there we do not find the mean depth of the chondrophys. In a rough estimate the latter might be set down at about three times the average thickness of the chondromyoplax. The general uniformity in the depth of the chondrophys makes it much easier to measure than the other layer, but still it has some variations in thickness which are not to be passed by, for more than one reason. In the first place they are variations in form as well as diameter, and secondly they are connected with structural peculiarities. These points will be developed as we proceed in our delineations of the outlines of the different subdivisions of the layer.

70. To begin with, we would state that the chondrophys is to all appearances a double layer; that is to say, it is differentiated into two well-marked strata (c, c^1), which, however, do not seem to be separable, like other adjoining layers. Still they have such an amount of diversity in character as to warrant us in taking particular notice of each by itself. In the first place, we will speak of them as if they were one, under the term, *the chondrophys*, inasmuch as they are inseparable; the one being found wherever the other is to be met with. At all points of the periphery of the umbella, except at the distal side of the bunches of tentacles (*fig.* 54, *c*), the chondrophys has an abruptly terminating, rounded-truncate edge (*figs.* 61, 62, etc., *c*) fitting into the concave-truncate border of the chondromyoplax (¶ 65–68); whereas at the points excepted (*figs.* 54, 58, 60, *c*), which are eight in number, the edge of the layer is bevelled off, so as to meet the chondromyoplax (b^1) at an oblique angle, the two overlapping each other as it were, the margin of the former lying exterior to that of the latter. The manner in which a thin layer of the opsomyoplax intervenes to prevent the actual contact of the borders of the chondrophys and chondromyoplax is described in a previous paragraph (66). In a longitudinal section of the body, in two different planes which meet at the axis, namely, one running through an anchor and along a partition, and one of the

muscular cords of the peduncle (*figs.* 37, 47, 47ª), and the other (*fig.* 37) through a bunch of tentacles and one of the genital halves, and just within the periphery of a longitudinal camera (τ^3) of the peduncle, a very good idea of the nearly uniform thickness of the chondrophys may be obtained.

71. From the anchor—which lies a little beyond the distal end of the partition—to the base of the proboscis where the partition terminates (ψ^5), there is a very slight but distinct and gradual increase in depth, and from the latter place to the entrances (*fig.* 50, τ^4) of the peduncular cameræ, there is no change; but, passing beyond that, the gelatinous mass abruptly expands and stretches to the very axis of the peduncle (c^1) and fills up all the space between the four chambers (τ^3). The relation of the several parts here mentioned is exhibited best in a comprehensive manner by making a transverse section of the peduncle (*fig.* 52), which at the same time displays the disposition of those portions that are concerned in the other longitudinal section (*fig.* 37). Taking the second course indicated, we find the chondrophys considerably thinner than the average at the margin skirting the distal side of the tentacular group (*fig.* 37, ϕ), and commencing with a sharp edge; but passing backward it rapidly thickens to the average measure and then stretches with unbroken uniformity to the apertures of the chambers (τ^3) of the peduncle, and thence to the very posterior end of the body with the same general thickness, but frequently indented somewhat deeply (*fig.* 51, c^1) in such a way as to render its free surface, which abuts on the camera, very ragged. That portion of it which forms the interior transverse lining of the truncate terminations of the cameræ is still more jagged than along the sides of the peduncle, and it is also much thinner (*fig.* 51, c^3). These indentations are frequently so deep as to completely pierce the chondrophys, and then they extend to the exterior wall (*ectophragma*) of the adherent disk. In a face view of them (*fig.* 19, τ^3) it becomes evident that they are so numerous and so disposed as to form a sort of network by running into each other.

72. By reverting to some previous paragraphs (57, 58) a partial description of this peculiarity will be found, and in addition something about the lateral connections of the posterior ends of the cameræ through irregular passage-ways (τ^5) in the gelatinous mass. To render our description here complete we will refer to those paragraphs for details concerning the adjoining organs, and fill up what is wanting by adding further minutiæ. These passage-ways are very easily displayed for observation by sections which divide diagonally opposite cameræ lengthwise (*fig.* 51, τ^5), and by a transverse cut across the peduncle just in front of the inner face of the adhesive disk (*fig.* 19). In the former may be seen the extremely irregular and even branching longitudinal projections (τ^5) of the passage-ways into the axial solid mass (c^1) of the chondrophys; and in the latter (*fig.* 19, at c^3) is the direct proof of how little of the chondrophys is left—a few columns—between adjacent cameræ by these extensive burrowings. The muscular cords (*fig.* 19, *r*) are scarcely exempt from these encroachments; at least their periphery is uncovered by this substance, and would be laid bare in some places were it not for the lining wall (*endophragma*) of the cameræ, which follows all these sinuosities to their minutest ramifications; and their posterior truncate ends are undermined by an occasional *diverticulum* (*fig.* 46, τ^5) from the main burrows. Sections (*figs*, 61, 62)

across the angles of the umbella disclose a rigid uniformity in the thickness of the chondrophys, and at the same time expose the abrupt, marginal juncture of the latter with the chondromyoplax, as explained in a former paragraph (66).

73. The *double layer* (70) which we have comprised under the name chondrophys, possesses certain dissimilar characteristics in each of its subdivisions, which lead us to describe them as if separate, although we do not believe that they are originally of diverse origin. We shall defer giving the details regarding these (¶ 197) until we come to the histological anatomy of this animal, and content ourselves with merely indicating the appearances which first catch the eye upon a cursory survey of the mass. In any of the sections mentioned above, it will be noticed that the chondrophys is composed of a comparatively thin layer (c^4), which forms the inner division, and of a very thick stratum (c), which is at least four to six times as thick as the other. It is a peculiarity of the thinner one that it terminates with a sharp edge (*figs.* 60, 61, 62, c^4) at this point of junction of the anterior and posterior parietes of the umbella, and therefore bears no part in forming the abrupt margin of the chondrophys. Again, the striations which traverse the thickness of this layer are much finer and closer together than those in the thicker stratum, and moreover they always, even in the peduncle, trend in one direcion, *i. e.*, in parallel lines from face to face; whereas those of the greater mass are comparatively heavy, and are remarkable for the regular and systematic manner in which they cross each other about the axis of the peduncle (*fig.* 52, c^1), there being no less than five distinct sets of decussating fibres at this point. (See ¶ 198 for details.)

74. *The gastromyoplax* (Pl. VII, *figs.* 74, 77, *o*; Pl. IX, *figs.* 98, 99, 103, *h*).—For the purposes of homology this term is better suited than another (*oömyoplax*, ovarian muscular layer) which would signify the restricted limits of this layer in the region of the reproductive organs of *Lucernariæ*. It is essentially an oömyoplax because it is developed only in and about the genitalia, and cannot be traced beyond the outskirts of the saccules (¶ 51) and the digitiform bodies (¶ 52). In regard to the latter, the presence of this layer in them as well as in the saccules tends to confirm their association as a part of the reproductive organs. But the oömyoplax is homologically identical with the gastromyoplax of the Strobiloid medusa-cephaloid, whose true oömyoplax is incorporated with another layer—the *opsomyoplax*. The term oömyoplax, then, can be used only as indicative of function and not of structural relation. We shall scarcely do more here than mention this layer, because it forms a part, though small, of the body-wall, and refer for all the necessary details to the paragraphs (135–137) on the reproductive organs, to which it strictly belongs in Lucernariæ. As the muscular cords emerge from the chondrophys of the peduncle and cut their way through the chondromyoplax (see ¶ 59 and 67) to enter the proximal ends of the partitions, a thin film of muscle is given off, just behind the base of the proboscis (*fig.* 47^a, ρ^3), and extends into the nearest digitiform bodies (γ). There it forms a layer (*fig.* 98, *h*) just beneath their outer wall, and then passes on in the same way to the others, and finally, without leaving its position on the under side of the *gastrophragma* (*figs.* 74, 77, *i*), it pushes its way along the saccules of the genital organs and, diverging there, runs as a distinct layer (*o*) beneath the exterior wall (i^1, *oöphragma*) of each capsule.

75. *The gastrophragma* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 48; Pl. V, *figs.* 53, 54, 58, 60; Pl. VI, *figs.* 61, 62; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 90, 91; Pl. IX, *figs.* 98, 99; Pl. X, *figs.* 127, 128, *i* to *i*7).—Excepting in the area over which the oömyoplax (*gastromyoplax*, 74) is spread, the lining wall of the general cavity of the body is applied directly to the inner face of the chondromyoplax (¶ 65) and the chondrophys (69), and follows them through all their divergences into the tentacles, anchors, genital saccules, and over the digitiform bodies; and faces every indentation, no matter how deep or narrow, nor how extensively ramified; not even excepting the jagged, tortuous passage-ways between the cameræ, at the posterior end of the peduncle (72). Since the nutritive fluid circulates within the immediate embraces of this layer, we have given it the appellation which heads this paragraph; but lest this might mislead the reader into a misapprehension of our views of its homological relations, it is necessary for us to state here that it is the same as what we have termed the *mesophragma* in the medusa-cephalid of Hydroida. It does not, however, bear the same special relations to the walls on each side of it that obtains in the Hydroida and Strobiloida, and it is this difference which constitutes one of the most essential grounds of argument in favor of separating the Lucernariæ from the other two orders. In the Strobiloida the gastrophragma is a *double* layer throughout the area over which the chymiferous fluids circulate; the chymiferous tubes, so-called, being merely spaces left where the juxtaposed faces of the anterior and posterior walls separate from each other. In the Hydroida the gastrophragma is a *single* wall within whose solid mass are hollowed a set of longitudinal and circular channels—the chymiferous tubes. In the Lucernariæ neither one nor the other of these modes is prevalent, nor is the gastrophragma uniformly continuous, since it is interrupted at the partitions where the chondromyoplax and chondrophys are brought into actual contact (67). It is always present as a lining wall—composed of a single stratum of cells—where there is a cavity, but in no case does it lie, a solid mass, between these strata. It always has one free surface throughout its length and breadth, which cannot be said of the corresponding layer, neither in the Strobiloida nor in the Hydroida.

76. This layer varies in thickness to a great extent, and is considerably diversified in the functional subdivisions to which it is apportioned. At the edge of the mouth the passage from the opsophragma (¶ 61, *fig.* 53, *n*3) into this layer (*i*7) is rather abrupt, as the latter suddenly thickens so as to exceed the former by about one-third in this respect, and retains this depth to the base of the proboscis. There it begins to thin off (*i*) and gradually diminishes to the dimension of the opsophragma; and, excepting in that part of it which covers the digitiform bodies (*figs.* 47A, 98, *i*5), it retains this measurement throughout the broader, open chambers of the umbella and the peduncle. Whenever it becomes a part of some organ it changes its character and, usually, its thickness to a greater or less extent. On the genital saccules (*figs.* 74, 77, *i*1) it is about as thick as in the broad areas about them, but it rapidly increases in depth by one-third as it extends over the digitiform bodies; and even by one-half at the ends (*fig.* 98, *C*) of the latter. At the tips of the intertentacular lobules (*figs.* 54, 60, *i*1) it is as thin as anywhere, but from these points until it fairly enters the cavity of the tentacles it thickens very rapidly and

to an enormous depth (i^2), amounting to at least twelve to fifteen times its measurement in the umbellar cameræ. In this case the tentacles are supposed to be extended to a moderate degree; yet when they are stretched to their utmost capabilities these proportions are not very much diminished. In the anchors the difference is still higher, but there is considerable irregularity owing to frequent indentations in the chondromyoplax, as a longitudinal section (*fig.* 47, i^1) of one of these organs shows; yet it amounts, here and there, to even twenty times as much as the thickness in the more open spaces. In a general way it may be set down as a rule that, at the newly forming part of an organ, or where new subdivisions of an organ are developing, this wall is thicker than in the older portions (*figs.* 58, 82, 83). In this layer is situated by far the larger part of the pigment-like matter which gives color to the body; and we may add, without unnecessarily anticipating what properly belongs to the histological portion of this memoir, that the nuclei of the cells are the principal elements in giving depth of hue, while the more widely spread, and scattered interstitial granules produce a general diffuseness and uniformity of tint.

77. *The vibratile cilia* (Pl. VII, *fig.* 74; Pl. IX, *figs.* 98, 99, 100, ω; Pl. X, *fig.* 109, ω) are truly the next deeply-seated parts of this organization, and although they cannot be included strictly under the head of walls, they at least form appendages to these layers, and, therefore, properly deserve mention here, with a statement in regard to the extent of surface over which they are spread. They occur in all parts of the interior, but are particularly abundant upon the genital saccules and upon one of the flattened sides of the digitiform bodies, but fail entirely on the others, and we believe also in the tentacles. Their structure and especial relations to the cells of the wall upon which they are situated will be found set forth, with full details, in the chapter on histology (Ch. VII, 201).

§ 11. *The Muscular System.*

78. *General distribution*—A few of the subdivisions of this system have already been mentioned, or in part described, in preceding paragraphs (44, 53, 57, 59, 64), and, therefore, we shall not here enter so fully into all the details necessary to an understanding of their topography and general form as we might otherwise do; but still, not to leave the sequences of our subject disconnected, we shall refer, from time to time, to such of those paragraphs as may be found desirable to complete the description. If we except the posterior parietes of the umbella it can be said without exaggeration that every subdivision of every organ of the body is supplied with some branch of the muscular system, and even the excepted region is affected almost directly by one of these subdivisions, for instance, that part of the *opsomyoplax* which, in the form of a thick rib, trends along the partitions where the chondromyoplax and chondrophys have their only lines of contact (48, 67, 68); or in that part—the doubtful umbello-peduncular region—where the muscular cords emerge from the peduncle and pass obliquely forward into the proximal ends of the partitions (¶ 59). In point of relative position the distribution of the various parts of this system is widely diversified; at one place it is either upon, or imbedded

in the *chondromyoplax*, or in another locality it is on the opposite face of the latter or it is buried in the solid mass of the *chondrophys*. If we trace it now through all its windings and variations of form we shall meet with the following subdivisions.

79. *In the proboscis* (*figs.* 47^a, 53, m^6) it is a very thin, uniform layer which, on the one hand, lies against the posterior face of the opsophragma (n^3), and on the other, overlies the chondromyoplax (b^7). It commences abruptly at the edge (ρ^1) of the mouth, in the angle just at the line of junction between the opsophragma (n^3) and the gastrophragma (i^7), and follows all the curves, undulations, and wrinkles of the manubrium, marking its way by numerous, delicate, longitudinal striations. It requires a magnifying power of at least two hundred diameters to determine that these striations are *fibrillæ*, and that they are not to be confounded with the heavier striæ and ribbon-like elements of the umbella proper, which can be seen with a very low amplification. Their nearest homologues are to be found in the tentacles and anchors, but the relations of the two are not altogether identical, since the fibrillæ of the latter do not form a continuous stratum like that in the proboscis. It is but just to say that a similar striation is discernible in all parts of this system; but we must observe that in the manubrium it is the only marked feature of organization, whereas in the umbella and the peduncle it is the arrangement of these features in folds, columns, etc., which, in the most conspicuous manner, indicate to the eye the *site* of the muscular subdivisions of the body.

80. *Muscles in the umbella.*—Beyond the limits of the proboscis the system is differentiated in such a decided, methodical manner as to form a prominent guide, among a few others, in localizing the surrounding organs and the specially endowed regions. It continues from the proboscis to the margin of the umbella without changing its position relatively to the opsophragma, but although still lying in front of the chondromyoplax, it is somewhat altered in conformation and in its connections with the latter layer. It will be observed in our figures (*figs.* 22, 37, 50, *m*) that a coarse kind of striæ pervades the anterior parietes of the umbella, but that it is not uniform in quality, and seems to be divided into two sets of four subdivisions each, alternating with one another. In the four areas which overlie the middle of the four umbellar cameræ the striation is simple, and extends from the proboscidial buttresses (ζ^1) with a wide flabelliform divergence, and merges gradually into a moderately broad, marginal band (m^1) of strong parallel striæ. Immediately over the eight genital halves (λ) this quality of striation is absent, and is replaced by the finer kind, only discernible, as in the proboscis, with a comparatively high power.

81. In the space included between the halves of each genital, and lying collateral to the partitions (ψ^2), we find the most evident expressions of strength and solidity to be met with in any part or organ of the body, excepting the peduncle. The striation here possesses more of the character, in appearance, of a banded surface, owing to the regular distances apart at which the striæ are disposed. They have a pennate rather than a flabelliform arrangement, but so situated, that, although they diverge from each side of the partitions along the whole length of the latter, they all tend obliquely to the margin (ψ^3) of the umbella, and there run gradually into those groups of deeply marked striæ which run, like a band (m^1) along the

periphery. The apparently jointed structure of the pennate bands does not belong to them, but is the result of the contraction of the muscular layer, along these lines, which wrinkles the opsophragma, at stated points, transversely to the trend of the bands. A few experiments with the point of a needle will soon convince one that the irritability of the animal may be exhibited by contractions at single points, or along certain lines, as well as by a general shrinking of the body. One of these bands may thus be impelled to contract so strongly as to produce heavy folds in the opsophragma along that line, while it remains quite smooth on each side of it. Before we enter into a more intimate research upon the structure of this part of the muscular system, we should make this superficial reconnoissance complete by taking special notice of the marginal terminus of the opsomyoplax, although it has already been characterized in a general way. This terminus has the form of a finely plaited border (m^1), the plaits running parallel to its sides, and fading out near the groups of tentacles. Except at the last place mentioned, it is well marked in character at all points of the periphery, but particularly pronounced (*fig.* 25, m^1) at the bases of the anchors; the latter category standing in strong contrast with its smoothness in the neighborhood of the tentacles, the homologues of the anchors.

82. We will proceed now to revise, from another point of view, the several areas which we have just passed over, commencing with those which are most directly continuous with the parietes of the proboscis. These we shall find between the corners of the buttresses (ζ^1) and the umbellar margin. By bringing the muscular layer here into profile view, by means of a transverse section (*fig.* 62, m), we disclose the fundamental element which lies at the bottom of the striation, noticed above. This turns out to be a more or less extended thickening of the stratum along stated lines, which run in the direction indicated by the striæ. These thickenings appear in the form of narrow ridges of varying height in other areas, but here they are quite low, and do not rise at very sharp angles from the general mass, yet they are of sufficient altitude to produce, by their comparative opacity, a distinct contrast with the transparency of the thinner intervals; and hence arise the lighter and darker lines, which have been spoken of as striæ. Approaching the margin of the umbella the striæ grow stronger, and the ridges become correspondingly higher, at first no greater in altitude than in breadth; but finally, as the marginal, plaited band is entered, they abruptly increase to the proportions of very lofty narrow and thin crests (m^1), with intervals of breadth equal to them, between their bases. At the less elevated points the ridges do not encroach upon the chondromyoplax (b) very sensibly, but as they become more prominent they plunge deeper into its anterior face, and within the marginal, plaited band they cut nearly through it, and, in fact, occupy as much, if not more, of the anterior parietes of the umbella along its border, than the layer in which they are imbedded, and have partially displaced. At last the muscular stratum meets the abrupt, convex margin of the chondrophys (c), close to the under surface of the opsophragma. This is not its termination, however; that is to be found along the line at which the inner layer (c^4) of the chondrophys thins out to a sharp edge; and in order to reach this place the muscle makes a final plunge between the abrupt convex margin

of the chondrophys (*c*) and the equally abrupt concave borders of the chondromyoplax (*b*), forming an intervening partition (k^1) there, and terminates, as just indicated, a few lines above. In such a precise, peculiar manner the umbellar division of this system intervenes between the juxtaposed margins of the two gelatiniform strata at all points in the periphery; not only along the sinuses of the octagon, but even at the distal side of the bases of the groups of tentacles and the anchors. The modes of approach to this terminus, though, are quite diverse in the several regions mentioned, and are, therefore, to be described separately.

83. We turn now to the ribbon-like pennations which diverge from the partitions. Their internal conformation is best exposed by a section across two of the corners of the octagonal umbella, with an intervening partition (*fig.* 61). By this we learn that the bands in question are the expressions of the thinner portions of the muscle which lie between less transparent ridge-like thickenings (*m*). The disposition of the ridges is peculiar to this region, and differs from that described in the last paragraph, inasmuch as the intervals in the present case are two or three times broader than the ridges. The latter are heavier and plunge deeper into the chondromyoplax than the ridges of the buttresses and the adjoining face of the umbella; in fact they reach half way or more through the thickness of this gelatiniform layer. We ought to qualify this, however, by stating that, as the muscle approaches the margin of the umbella, it loses its folds for a short distance, and is as thin and smooth as that portion of it which lies in front of the genitalia, but soon it becomes ridged again, and then joins the marginal band (m^1). One more peculiarity is to be mentioned, and that is to be found along the line of the partitions. Here the muscle attains to its greatest thickness and massiveness, assuming the form of a broad rib (m^4), which is about half as thick as it is wide, and occupies the whole depth of the chondromyoplax, excepting that part of it (b^5) which constitutes the mass of the partition. It is not homogeneous, by any means, but on the contrary, as a transverse section shows, it appears to be deeply folded lengthwise; the folds, where cut across, resembling the ends of so many divided threads. Surveying it in a longitudinal section (*fig.* 64, m^4), the folds evidently run parallel with each other, but not continuously, some fading out while others begin, and all trending in one general direction. At the proximal ends (*fig.* 47ᴬ, ψ^5) of the partitions, the folds run into the larger conduplications of the muscular cord (r^2) just as it comes forward from the peduncle and enters the umbella.

84. *The marginal band* of muscle is so strongly marked by its ridges that it appears, at first sight, as if it were a distinct strip, a deeply plaited hem; but we have already seen (¶ 82) that it is continuous with the neighboring opsomyoplax, and that its conduplicated physiognomy is due to the ridges which project from the general mass into the chondromyoplax. When, therefore, we speak of it as the marginal muscle, or band, it must be understood in this light. In the neighborhood of the tentacles its ridges disappear, and it then ceases to be recognized as anything more than a thin, uniform stratum (100), indistinguishable from the rest of the muscular layer; while opposite the anchors (*fig.* 25) it retains a considerable proportion of its ridges (m^1); yet these are variable in number and strength. The true opsomyoplax is strictly confined to the parietes of the umbella, and

wherever it passes beyond that, although not dissolving its continuity, it becomes another subdivision of the system, for instance, that of the tentacles, or of the anchors. At the anchors its junction with them is indicated by the prolongation of the ridges of the marginal band (m^1) into the stem of these organs (at m^5), and may be readily traced by a surface examination; but since all the ridges fail in the region of the tentacles, the relation of this layer to its continuation in the latter organs can only be determined by an actual section of the parietes thereabout, thus displaying a profile of its thickness, and the course it takes in making the connection.

85. *The gastromyoplax*, or *oömyoplax* has already received all the attention that is necessary to define its position and connections in reference to its general surroundings, and, as we have said in a preceding paragraph (74), since it is wholly devoted to the reproductive organs and their appendages, we shall defer a special description of it until those organs come under particular examination; but, inasmuch as it is a branch of the great subdivision which converges at the proximal ends of the partitions, and concentrates in the peduncular cords, it is eminently proper to repeat here what has been said in reference to its mode of junction with the latter, and perhaps to add some other matters of interest. Contrasted with the opsomyoplax it is very thin, and might readily escape the eye of the observer, unless his attention were drawn to it by the activity and evident muscularity of the digitiform bodies. Between the necks of the genital saccules it is thickest; it thins very sensibly as it passes into the latter and into their appendages, and is a mere film where it folds over the proximal ends of the partitions and joins the great cords of the peduncle. (See ¶ 76.)

86. In the *tentacles* the muscular system (*figs.* 43, 54, 90, 91) ceases to be a continuous layer, but still it retains the same relations to the opsophragma and the chondromyoplax that it had in the umbella. The difference consists in this: instead of being a distinct stratum, it is, as it were, split into a large number of threads which are grouped in bundles (*fig.* 90, m^2) of two, three, or four, more or less mutually overlying; the bundles being separated from each other by varying intervals, and trending lengthwise of the tentacles. This accounts for the longitudinally ribbed appearance (*figs.* 43, 54) of these prehensile organs when viewed with a low power.

87. The *anchors* (colletocystophores, § 13) possess a modification of the muscular layer identical with that in the tentacles, which may be as conveniently traced in their youngest stages of development, before their tentacular nature is disguised; but, in consequence of the great changes which take place, by the thickening of the outer wall and the development in it of the adhesive vesicles (colletocysts, § 27), the full-grown organs present great difficulties in the way of tracing the course of the bundles of muscular threads. We have succeeded in doing so, notwithstanding, and shall describe the results in detail in the special paragraphs (§ 13) on these organs, since the relations of the fibres in question cannot be properly understood without a knowledge of the peculiar conformation of the several strata which constitute the anchors. This reason will apply with equal force to the tentacles.

88. The *muscular cords* (*figs.* 19, 46, 47^a, 50, 52, 113, 117, r to r^3) of the peduncle necessarily demand our notice here, as a part of a general system, although

their peculiarities have already been nearly exhausted in a former paragraph (59); in fact there is nothing left to be said in regard to their relative position in the peduncle, nor in reference to their mode of connection with the other subdivisions of the system, but their structure yet remains to be described. In that is embodied the most singular of all their qualtities. They are in reality, what they appear to be upon superfical examination, cords whose mass is so deeply furrowed lengthwise that they could almost be said to be groups of four bands united by one of their edges. The nature of this mode of subdivision of the cords becomes quite clear when they are cut across (*figs.* 52, 117, *r*). Here we see the general outline of the periphery, as well as the minor details of the surface in all their fullness. Each cord, it appears, has a sectional outline resembling an obtuse-angled triangle, two of whose sides face away from the axis of the body, and the third and longer one is convex and faces toward the axis. It might well be compared to a triangular prism. Its mass is split nearly through to the apex of the triangle, so as to be parted into two divisions of equal size; and each moiety (*fig.* 117) is again penetrated by a fissure, which does not extend more than about half way through it, but trends, like the first one, toward the obtuse angle. All of these subdivisions, in fact the whole surface of the cord, is still farther indented by deep flutings which give it the appearance of being finely ribbed (*fig.* 113). A highly magnified view of a transverse section of one of these fluted divisions (*fig.* 117) presents the aspect of a deeply lobed triangular mass. Thus it is that the prismatic cord imitates, in a more concentrated form, the deeply ridged muscular layer of the umbella; the idea is the same in both, but here it is carried out to the extreme, apparently serving to increase the surface of contact between it, the moving agent, and the gelatiniform mass (c^1) about it. At the posterior truncate end the furrows terminate, for the most part, abruptly; but a few follow it beyond that, along the course of the gradually narrowing muscle, as it bends at a right angle (*fig.* 46), and comes to a point in the middle of the adherent disk (*figs.* 19, 46, r–r^1). And so it is at the anterior end of the cord, where it gradually decreases in diameter (*fig.* 47ª, r^2) until it penetrates the chondromyoplax, and then rapidly expands, in the umbella, into a flat mass, the opsomyoplax (m^1). There we find the transition from the deeply fluted condition of the prismatic mass of the cord into that of the heavily ridged and grooved stratum which pervades the area on each side of the partitions. The greater diameter of the cords is about equal to the shorter diameter of the pedicellar cameræ, and from one-third to one-half the breadth of the space between the latter. We have already stated that they are completely imbedded in the chondrophys, but the precise relation which they hold to the decussating fibres of that mass is yet to be illustrated; and, since that would involve a description of the minutest structure of the gelatiniform column, we must postpone the subject to the chapter on histology (198, § 25).

§ 12. *The Tentacles.*

89. *Basis of Attachment.*—The tentacles (*figs.* 17, 22, 54, ϕ to ϕ^3) are nothing more nor less than hollow cylindrical protrusions of the anterior parietes of the

umbella, as if its constituent layers had been pushed outward, at stated points, into finger-like projections, and had become fixed there. Such we may see they are, essentially, if we follow their course of development—their budding—as any one can do, either with young specimens or old ones in hand. The groups into which they are gathered number eight in all, and are situated singly on each corner (ψ^1) of the octagonal umbella, close to the marginal junction of its circumoral and aboral parietes, the bases of the older, most distal tentacles (*fig.* 54, *D*) actually abutting against the margin of the latter. They are, however, distinctly separate from that, not only by virtue of their position, but also in the quality of their walls; and prove to be, in their minuter details, identical in kind with the layers of the circumoral parietes from which they arise and are directly prolonged. From a taxonomical point of view they are very peculiarly situated, no single bunch being complete in regard to symmetry, neither in reference to the relative position of the tentacles among themselves, nor in their relative ages and sizes. In as few words as possible we express their arrangement by saying that they are one-sided, asymmetrical bunches. Yet their very asymmetry is symmetrical; for if, of two groups adjoining a partition (ψ^2), one group preponderates on the side nearest that partition, the other also leans toward it, and thus they present a symmetrical relation to each other similar to what we find in the anisoscelean triangular halves (λ) of the genitals. If we combine, now, the functional relations of the regions comprising the genitalia with the apparent taxonomical mutual reference of the tentacular groups which lie opposite those regions, it becomes evident that the umbella is subdivided into four symmetrical portions, each separated from the other by the areas which extend from the corners (ζ^1) of the proboscis to the margin. Such a prominent relationship would seem to demand that these subdivisions should stand in the principal planes dividing the body into right and left, and into dorsal and ventral segments; yet, not only would the animal be just as symmetrical if divided along the planes intermediate to these, *i. e.*, planes prolonged from the corners (ζ^1) of the proboscis, but there is every reason to believe that the latter way would be the right one. Why this is so cannot be entered into here, but our reasons for so believing may be found, expressed in full, in the section (Part XV) on the "criterion of symmetry."

90. *Taxonomy.*—The asymmetry of the groups of tentacles referred to in the last paragraph may be most conveniently illustrated in the mode and succession of development of these organs in the young, before they become so numerous and crowded as to render their relations to each other more multiplied and complicated. A special section or paragraph (149, 150, 155) has been devoted to this in a subsequent chapter (VI), and for the sake of clearness we would ask the reader's perusal of that part of the subject before proceeding with what we have now to present. The guide to the disposition of the members of each group is a single tentacle, situated on the distal side, and, as near as the eye can judge, about opposite the middle of the bunch (*figs.* 17, 22). We should state, before proceeding farther, that the usual number of tentacles in the adults is about one hundred; but not infrequently very large specimens are met with which possess as many as one hundred and twenty in each bunch. Now, for certain purposes, such multitudes,

so far from hindering the investigation of their taxonomy, are of eminent assistance, especially in guiding the eye through their singularly well-disposed ranks. Although they do not actually map out their arrangement on their foundation, they nevertheless force themselves upon the attention of the observer, and lead him to infer, at a glance, that they are by no means scattered indiscriminately over the area which they occupy. When they are quiet, and extended in full vigor, the eye is struck with their apparently ranked arrangement, as if they stood in file. Frequently the files seem to cross each other in systematic order, like the decussating lines on the milled back of a watch; but the ranks are particularly noticeable when the body is viewed directly from in front, looking along its axis, as it were (*fig.* 22, and cut no. 1). Then one may count as many as eight or ten rows, trending from the proximal to the distal side of the group; and usually it is clear that one of these rows is more prominent than the others on either side; that the tentacles composing it are, on the whole, larger than in the neighboring rows. If now this file be followed to its distal end, it will be noted that it runs through the middle of the group, or thereabouts—certainly nearer to that line than any other file—and that it terminates in the largest tentacle on that side. That is the tentacle which we have spoken of, a few lines back, as the "guide;" it is the primary, single, *oldest* tentacle. There is no mistaking it, nor its position, in very young animals (*figs.* 121, 125, no. 1) where the members of a bunch are few.

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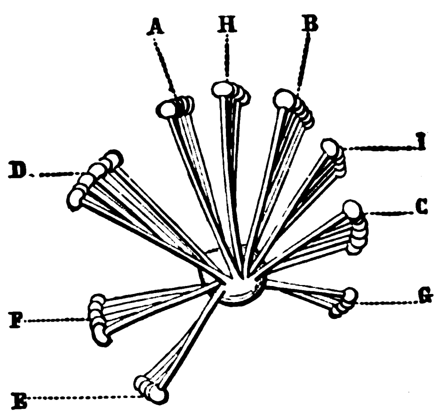

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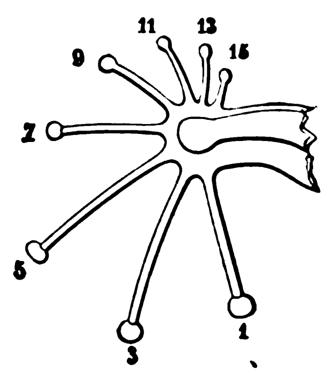

91. Keeping the main file in view while taking a general survey of a group, the preponderance of the multitude on one side of that row is quite marked; the oval outline of the bunch appears gibbous; and if we plunge to the bases of the tentacles we shall find that the area from which they arise is excentric to the oval which circumscribes their tips (cut 3). We naturally infer, therefore, that the general physiognomy is expressive of the arrangement of those details which combine to make up the whole; and this is true in one sense; but, as we shall discover presently, the outlying portions are not capable of being reduced to that rigid test which would prove what their real relations are. Their numbers, and, above all, their mobility are serious, insuperable obstacles in the way of such a determination. What at times appears to be a single file is, in reality, formed by the combination

of two rows, or perhaps three; the true rows lie so close together that the slightest possible swerving of the tips of the tentacles to one side brings those of neighboring ranks so nearly into line that the eye fails to detect the want of perfect continuity in it. It must be kept in mind here, though, that the globose tips of these organs stand at a considerable distance apart, and that their range is over a long line which is arched in the direction of the plane in which the file trends (cut 2). The eye,

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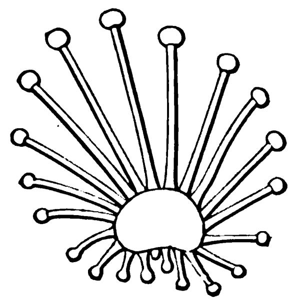
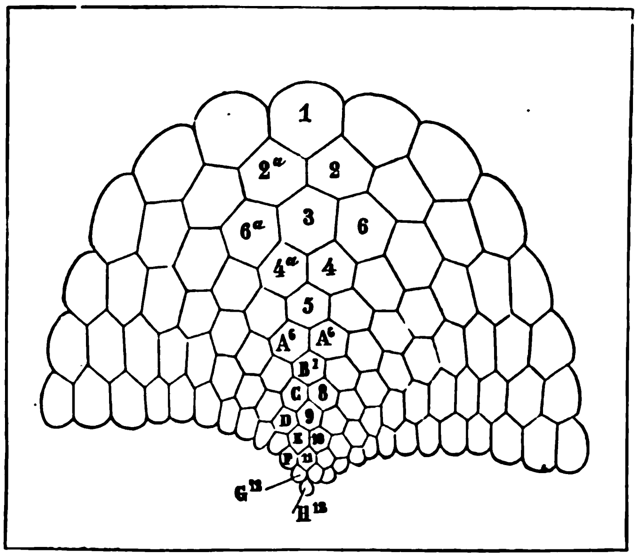


therefore, cannot take in the whole file of tips at once, but must pass from point to point, and in so doing the slight divergence from the plane is not noticed. Still it is possible to determine to a certainty whether a file is single, or double, or triple, or more; but we must confess that it was not until after we had become familiar with these bodies and their various attitudes, by long and painstaking observation, that we could come to any definite conclusion, even as to their general arrangement, much less in regard to their special taxis.

92. The clue to the one-sidedness of a group was not detected until the process of development had been traced in young animals. It is true that by following any one tentacle of a file down to its base, where it was in contact with others all around it, we could determine whether it originated from the same line as the others next to it in the apparently single row above; but the large number of the group taken together, and the crowded state of the numerous younger tentacles was a great hindrance to a true appreciation of their relations. The clue once discovered, though, in the young animal, it was no difficult matter to see the trend of the development of these organs, and a reason for the asymmetry of a bunch in the adult; but still, such were the obstacles arising from numbers, approximate identity in size, the convex surface over which they were spread, and in particular the mobility and unstable condition of this surface in the region where the younger tentacles were budding and growing, that it was impossible to determine the exact status of each one, either in regard to dimensions or relative position. This has been accomplished with the fullest satisfaction in the young (¶ 149, 150, 155); showing, incontestably, that the older tentacles preponderate on that side of a group which lies next a partition, but the investigation was not carried on far enough to form a groundwork for the deduction of a mathematical formula of taxis, although it seemed quite probable that it was a rather high figure. Our diagram of the taxis (cut 4) of a group of an adult animal, must be taken, therefore, only as approximate and general. The value of the diagrams of development in the

young is positive so far as the relative age and position of the tentacles are concerned, and the reader will not do amiss to consult the paragraph devoted to their elucidation, while following out the description of the adult forms.

Cut 4.



93. The resemblance of the accompanying diagram (cut 4) to a segment of a honey-comb is obvious at a glance, not only in the relative position of the tentacles, but also in the shape of the outline of their bases. The proportions in size, however, are altogether different. Except on the periphery of a group, every tentacle is surrounded by six or, perhaps, sometimes five others, and, as they are all in contact, they naturally compress their bases into the polygonal forms which we have exhibited in the diagram. Those on the periphery are rounded on the free side, and consequently seem to prove that the many-sidedness of the others is due to a mutual restriction of their limits. The asymmetry of the group may be well expressed by comparing its outline to an anisosceles spherical triangle, projected on a plane in such a way that its longest side is convex and the two others concave. The longest side will then correspond to the distal border of the group, and the next longer will trend along that border which faces towards a partition. Generally speaking, the oldest tentacles lie nearest the convex or distal side of the figure, or rather, we might say, are embraced in the angle formed by the two longest sides; and the site of new developments is near the shortest side, or verges in that direction. When, now, the tentacles appear to be in files one may observe that they all diverge from about one point, and that that point is at the junction of the two shortest sides of the triangle. Of course it will be seen that those in one row alternate with those in the next on either side, and that, inasmuch as those on each side of any one file fit into the intervals, and actually meet at their bases between the succeeding tentacles of that file, a very slight divergence of two lateral rows may bring the globose tips so nearly into exact line with those of the middle one as to make them appear to form a perfect continuity.

It is a very noticeable fact that the tentacles on the distal side of a group are not the longest, nor, on the whole, the largest; and it is all the more remarkable and unexpected because some of them are the oldest, and usually appear to be the stoutest. This difference is most observable when a file is brought into profile (cut 2, p. 43); then the second, third, and fourth appear to be longer than the outermost one, and sometimes the third the longest of all.

94. *The form* (*figs.* 42, 54) of the tentacles in *Haliclystus*, and we have good reason to believe in all Lucernariæ, is unique among Acalephæ. They do not taper. In the young this seems not to be so, strictly speaking, but that is when they are in a formative state; and even then we do not recognize the distinct taper which is so marked in the globe-tipped tentacles of Coryne, Pennaria, etc. When fully extended a tentacle arises from its base abruptly, with the proportions and form of a very slender cylinder (*fig.* 42), from twenty-four to twenty-eight times longer than thick, and terminates in a depressed globose mass (ϕ^2), the diameter of which is from two to two and a half times greater than that of the shaft (ϕ^1).

In very old specimens the globe (*fig.* 41) very commonly has three times the diameter of the cylinder, but from this downward, among the younger members of the group, the difference gradually diminishes (*fig.* 34) until it disappears, and the end of the shaft is merely rounded (*fig.* 54, A). A group usually presents more or less of a bristling look, as if the tentacles were rigid and inflexible. This is owing to the manner in which they comport themselves with reference to each other; always free from entanglements, notwithstanding their large number, and rising, with an abrupt, clear stretch, perpendicular from their arched foundation. Frequently the rigidity of a group is relieved by a graceful curving of the shafts all in one direction, as if by common consent, and again, without any apparent cause, they assume an angular port, the shaft being bent more or less abruptly, at one or two points, into a zigzag form. Occasionally we may see a tentacle undulated (*fig.* 36) from tip to base by numerous closely succeeding curves, which alternate on opposite sides with such regularity that they have the appearance of being the turns of a helix. The longitudinally ribbed surface is not real, but arises from the conspicuity of the bundles of muscular fibres which lie just beneath the outer wall. There is evidently such a limit to the extensibility of a tentacle that it can never assume the proportion of a mere thread, such as we see in Hydra, and the scyphostoma of the Strobiloida; and we are indeed inclined to believe that it is more restricted in this sense than in most Acalephæ. The form never passes beyond the proportions of a very slender cylinder, not even approximating a filament in the relations of its length to its breadth. By designating it as a slender shaft we express its relative dimensions in the best general terms obtainable. Its positive length is from one-sixth to one-fifth of an inch when the umbella measures one inch across. The contractility of these organs is also subjected to certain recognizable limits. When disturbed they usually retract so as to be quite thick in proportion to their length; and if the irritation is persisted in they may become still farther shortened, until the length is to the diameter as four or five is to one. The spheroidal tips do not seem to partake in the general contraction to any appreciable extent. The instinct of self-preservation appears to be exhibited by the consentaneous contraction and inrolling of the tentacles, and a subsequent folding together of the sides of the umbella (*figs.* 14, 15); whilst the activity demonstrates itself by a wide expansion of the body, a reversion of the periphery of the umbella, and an extreme elongation of the tentacles (*fig.* 1). Any one of the latter is movable singly, or a number of them follow each other in one file, with a succession of quick, abrupt flexions of the tip toward the base, or, again, the whole bunch is carried toward the mouth by the arm-like corner of the umbella; especially if the tentacles have come in contact with an object fit for food. The prehensile apparatus in this operation is to be found in the urticating organs (*cnidæ*, or *nematocysts*). Their structure and mode of action are fully described in the chapter on Histology (Chapter VII). Normally a tentacle is single, but now and then one encounters a double specimen; it may be forked from near the base, or at the ends, only the globose tips being double, sometimes one spheroid supports another on its side (*fig.* 38), or at some point of its periphery. Our figure (*fig.* 54, C) represents a tentacle which is double for about half its length. The prongs of the fork are scarcely smaller than the main shaft, and do not differ from it or the corresponding region of the other tentacles in any respect.

95. The *globose tip* (*figs.* 41, 42, 54, ϕ^2) is always broader than long, and is set, like a cap, on the end of the shaft, in such a way that the axis of the one coincides with that of the other. The form of the spheroid varies to some extent, but always, it would seem, at the end, where, at one time, it projects from the convex surface like a very low cone (*fig.* 42), or, at another time, it is considerably depressed (*fig.* 41) below the general level. The latter is particularly noticeable in the oldest tentacles, the depression being carried to such a degree that the spheroid has rather the appearance of a very thick disk with rounded edges. The thinness of the walls in such cases, and their consequent semi-transparency, has given rise to the assertion, put forth by some naturalists, that the tip of the tentacle is perforate. But that this is a mistake may be proved, not only by careful inspection, especially of the younger specimens, but also by the fact that the depression is frequently at the side (*fig.* 39), and, moreover, two and even three (*fig.* 40) occur at one time at diverse points on the periphery. They are formed at will, and are evidently due to the action of the muscle which immediately underlies the outer wall. The opacity of the spheroid of the largest tentacles is so great as to render it completely impervious to the powers of the microscope, unless it be compressed into an unnatural condition. Younger tentacles, however, are more transparent and allow a thorough investigation of this part without subjecting them to any artificial preparation. Its prickly and dotted appearance (*figs.* 43, 44) is produced by numerous nettling organs (*nematocysts*) which are embedded just beneath the surface, and the color and opacity are owing principally to the intercellular pigment masses which lie at the inner face of the exterior wall. This accounts for the fact that they are darker near the centre than at the periphery.

96. *The walls of the tentacles* are identical in number with those of the foundation from which these cylindrical shafts arise; but they differ considerably in certain qualities, such as proportionate thickness, and some minor details of organization. We have, then, in them direct prolongations from the opsophragma (¶ 61),

the opsomyoplax (64), the chondromyoplax (65), and the gastrophragma (75). Although the differences between the same walls in the tentacles and in the umbella are in certain points very great, the change from the one to the other is by no means abrupt, as may be seen while we enumerate and describe them, each in its turn passing from without inward. It would be well to bear in mind, during this description, that the tentacles are fully extended.

97. *The opsophragma* is the foundation of the outer wall (*figs.* 54, 90, 91, n^1) of the tentacles, and so far as the latter is confined to the shaft it has about the same thickness, excepting at its distal end, where it is slightly incrassated and forms the neck-like junction with the spheroidal tip. To complete its course, though, it enters the globose mass (*fig.* 54, ϕ^2), in fact it almost becomes the mass itself, since it forms so great a proportion of it; and yet it consists of but a single stratum of cells. This is effected by a very abrupt and enormous thickening of the layer, so great, indeed, as to equal fully one-third of the diameter of the spheroid. This leaves, then, only a central third to be occupied by the other walls and the cavity of the organ (see also *fig.* 48, ϕ^2, n^1). The thickening (*fig.* 35, $\propto^3$) of the wall at certain points on the shaft, which is to be met with now and then, although quite rarely, is not of the same character as in the globose tip, but is a tendency to carry out what is so fully expressed in a normal way in the anchors (¶ 166, etc.). But more of this when we come to the description of the latter. There are no adhesive vesicles in the tentacles. We have already spoken of the apparently furrowed and ribbed appearance of the shaft (¶ 94), and referred it to the lumen of the underlying bundles of muscular fibres. At times the phenomenon is really on the surface of the outer wall, or within its thickness, and is produced by the peculiar action of these fibres, or at least it seems to be so, for along their course the cells of the wall in question are arranged in lines, and, moreover, they are elongated in that direction. It can scarcely be denied that the muscles are at the bottom of this singular feature, and also that they cause the wrinklings in lines running in the same course (see ¶ 202, A).

98. *The tentacular muscles* are not only the most important element of the prehensile organs, but also the most conspicuous. As we have seen above, they lend largely to the physiognomical character of the shaft. We speak of this motor apparatus as muscles, and not as a layer, and we do this advisedly, for the fibres do not form a continuous stratum, but the latter is, as it were, split into strips or threads (see ¶ 86), and these are grouped into bundles (*figs.* 90, 91, m^2) of two, three, or four. And again we notice that these fibrillæ do not lie in one horizon but are more or less superposed, and even mutually intertwined, thus warranting us in using the term fibres for their combined forces. Still there are here and there traces of a tendency to form a continuous layer, judging from the manner in which a fibrilla wanders now and then across the interval from one fibre to another. On the whole, the fibrous bundles run from the base to the tip of the shaft in parallel lines, and are so evident to the senses that they can be counted very readily. By a careful handling of these irritable creatures, taking the precaution not to disturb them by any sudden movement, but always slowly and steadily, and with no little patience, turning them from side to side, or even over and over, we have succeeded

in counting the number of fibres which lie in the circumference of the shaft of a tentacle. According to our notes there are, at least, as many as fifty in the oldest shafts.

99. In this connection it will not be out of place to say a word in regard to our method of avoiding the main obstacle in the way of preserving the natural proportions of the various parts of the organization. In the beginning of our investigations the constant and extensive contraction of the body was a source of annoyance whenever it became necessary to lay open any region with the knife. Finally we discovered that under persistent handling the body lost its irritability, and afterward it struck us that if we could but avoid or lessen the shock of contact the results would be not so violent. Upon this we always placed our instruments in the neighborhood of the body with caution, and sometimes took the pains to let the animal bring itself in contact with them, as if training it to the presence of a foreign object. Brass seemed to be particularly objectionable, even though it did not actually touch the body; probably tainting the water by decomposition, or perhaps by inducing electric currents in it. On the whole, well polished steel needles served our purpose best, taking care to renew them as soon as rust appeared on their surface. With these carefully ground down to lancet point and edge, many of our sections were made with scarcely a sign of impatience on the part of the animal. The slowness of the process was certainly trying, not only to the patience, but also to the endurance, for the utmost steadiness of hand was indispensable to success. Nor did we find that cutting with a very sharp instrument was as irritating as pressure with a dull one; the sharper the blade the less the resistance, and consequently a diminution in weight, and in the diffusion of it. We were simply applying a well-known physiological phenomenon, viz., the confused sense of the contact of two closely approximated points upon the surface of the sensitive membranes. After using the precaution to observe the exact condition of the region to be operated upon, and allowing the parts to recover from whatever little contraction they had been excited into, through the division of their substance by the scalpel, we could proceed with the confidence that whatever distortion might appear did not amount to more than the body could be supposed to assume in many of its most normal attitudes. Even the high muscularity of the tentacles did not prevent us from obtaining a fully expanded transverse section of the shaft, and applying a very high power to it. The crushing blades of scissors were always avoided if possible, although even these seemed not to disturb some parts of the body—the region of the chondrophys in particular.

100. The *chondromyoplax of the tentacles* (*figs.* 54, 90, 91, b^1) is coextensive with the muscular system of these organs, and forms the next to the innermost layer, lying intermediate to the gastrophragma (¶ 75) on the proximal side and the opsomyoplax (¶ 98) on the distal face. It preserves all the characteristics of the foundation (¶ 65–68) from which it is prolonged, and we need not therefore repeat them here. In a fully extended tentacle it is not much thicker than the outer wall. Its depth is pretty uniform from the base to the end of the shaft, but diminishes slightly as it enters the globose tip. There it terminates in a rounded closed extremity, and contributes to swell the mass of concentric layers, all, like itself, per-

manently imperforate. At the bases of the tentacles this layer is uninterruptedly continuous from one shaft to another, but in the passage it varies largely in thickness (*figs.* 54, 60, b^5), since its proximal side is drawn out into heavy irregular ridges and bosses (π), which constitute the main bulk of the large solid, *intertentacular lobules* (¶ 103). We should not forget to mention, also, that, as the distal tentacles of a group border close upon the line of junction between the circumoral and aboral parietes of the umbella, the chondromyoplax of the shafts comes to an abrupt terminus at that line; and, moreover, we would add, that the muscular fibres of these organs project from their basal ends and form a continuous stratum there, lying, like a partition (*fig.* 60, k^1), between the umbellar chondrophys (c) and the chondromyoplax (b^1). Laterally, as we have already pointed out (¶ 84). it is continuous with the marginal muscular band of the umbella, but is, strictly speaking, homologous only with that part of its border which lies between the termini of the two gelatiniform layers just mentioned.

101. The *gastrophragma* or lining wall (*figs.* 54, 60, 90, 91, i^2) of the tentacles is their thickest layer. Excepting a slight diminution at the apex of the shaft, we find this stratum has a uniform thickness throughout its length until we come to within a short distance of its base. Here a marked change takes place, and what was once an enormously deep wall, although composed of a single layer of cells, measuring from one-fifth to one-fourth the diameter of the tentacle, rapidly thins out (*fig.* 60, i, i^1) backward to the slender dimensions of the lining wall of the umbella soon after it passes beyond the entrance to the main cavity, in fact before it reaches the ends of the intertentacular lobules, where it is virtually the umbellar gastrophragma (¶ 75). The proximal face of the lining wall of the tentacles is particularly well marked; not so much, though, by any inherent characters as by the dark, irregular pigment granules (*fig.* 90, c^2) which crowd into the interstices and across the inner ends of its prismatic cells, lying so thickly as to almost tempt one into considering them bodily as a distinct stratum. They also serve to light up, by contrast, the boundary of the cavity which they cover, and they are eminently useful in assisting the eye to follow the continuity of this cavity into the umbellar chamber.

102. The *hollowness of the tentacles* is unquestionable, and more than that, they openly communicate (*fig.* 60, ϕ^3) with the main cavity of the body. It has been asserted by some naturalists that they communicate only with the lobules at their bases, which have also been described as hollow, and compared to the ampullaceous sacs at the basal ends of the ambulacra of Starfishes.[1] This is altogether untrue, the lobules being perfectly solid and, moreover, interbasal, instead of being direct prolongations from the tentacles. In the largest, full-grown specimens it is an easy matter to introduce the head of a fine cambric needle between these lobules and far into the cavity of the tentacles. It is true that the passage is not broad after the entrance has been fairly made, but it is quite distinct in the young, where the lobules are not developed until some time after the first tentacles appear, and the entrance to the tentacular cavity is quite broadly open; and the same may be observed among the budding tentacles of old individuals.

[1] Milne-Edwards and Haime, *Hist. Corall.*

103. *Intertentacular lobules* (*figs.* 54, 56, 60, π). The reader, no doubt, has learned by this time that these bodies are internal prolongations of that part of the parietes of the umbella from which the tentacles take their origin. Their relative position in regard to the latter might well lead a hasty observer to infer their similarity to the ampullaceous sacs of Echinodermata; but no very prolonged investigation is needed to determine that they have not the form of sacs, and that they are irregular, thick ridges which here and there anastomose into a sort of network (*fig.* 56), and send out, from scattered points, more or less flattened, irregularly oval lobular processes. The general trend of the plane of the greater diameter of the latter is parallel with the anterior and posterior parietes of the umbella. The depressions between the ridges of the network are the vestibules of the entrances (ϕ^3) to the tentacles; and the lobules, with their ready flexibility, suggest a valvular function which they might perform about these apertures. They consist of only two layers (*fig.* 60), the gastrophragma (i^3) and the chondromyoplax (b^5), and neither of these is strictly muscular, although we have elsewhere (¶65, 196) suggested that the chondromyoplax is only one undeveloped portion of the muscular layer (opsomyoplax). That would seem to be true here, if we may judge from the irritability and activity of these bodies; or it is possible that the gastrophragma is underlaid by an excessively thin muscular stratum which has escaped our eyes. The surface wall, or *gastrophragma* (i^3), has the same dimensions as in the more open areas of the general cavity, but is particularly characterized here by the dense deposit of pigment matter over its surface. This accounts for the dark patch of color so noticeable at the proximal bases of the tentacular groups, and which remind one of eye-spots, as the body is viewed from in front. The *chondromyoplax* (b^5) is an actual thickening of the mass with which it is continuous, and not a lateral projection from it; so that the length of a lobule is the measure of the depth of this layer. This is proved by the course of the fibrillæ, which pass in direct lines from the distal surface—lying between the bases of the tentacles—to the innermost free ends of the lobules.

§ 13. *The marginal adhesive bodies* (*Colletocystophora*), *figs.* 17, 22, 23, 24, 25, 37, 45, 47; a to a^8.

104. *Form and Position.*—The most attentive examination of an anchor in its extreme old age would not lead one to suspect that it was once a mere tentacle in form, proportions, and general structure. The proofs that this is so may be found in abundance in the section on Embryology (Chapter VI). We only wish, here, to draw the parallelism for the sake of their homological relations to the regions of the umbella when compared with the tentacles. There are eight of these bodies attached singly (*figs.* 17, 22, 37, a) to the eight intertentaculiferous margins of the umbella, exactly half way between the angles (ψ^4) of the octagon. Those four which lie opposite the partitions of the umbella are slightly longer than the other four, and the average length is about equal to the diameter of the peduncle. They consist of a short, thick stem (*figs.* 23, 24, a^1), or neck, supporting a heavy, flattened, ovate mass (a^3). The neck is attached to one of the flattened sides, and

near the broader end, at an acute angle to the longer axis of the oval. A profile (*fig.* 23) of the anchor reminds one of the spheroidal tip of a tentacle, asymmetrical in outline, and attached obliquely to a shaft which is broader than it is long. Defining the contour of the ovate mass more closely we should say that it is convex on the distal or posterior face, and hollowed by a broad furrow (*fig.* 24, α^6) which trends along its mid-line, on the proximal or anterior face; it is, on the whole, comparable to a date-stone, leaving out the greater proportionate length of the latter, since the ovate mass of the anchor is scarcely more than half again longer than broad. In their usual attitude the anchors are reflexed posteriorly over the margin of the umbella to a greater or less degree, and sometimes so strongly that from one-half to two-thirds of the ovate mass is hidden from sight when the body is viewed from in front (*fig.* 22). The anchor proper is altogether an offspring of the anterior parietes of the umbella, but a part of what appears to form the stem is a projection or ledge (*fig.* 25, β^1) stretching out from the border (β) of the posterior parietes. The line of junction between the ledge and the true stem is clearly marked by the margin of the muscular layer.

105. The stem of the anchor contains all the elements of the shaft of a tentacle, and these were originally disposed in like manner; but at the present age they are considerably altered, principally in their direction. This applies in particular to the muscular fibres, which are so conspicuous as to demand attention among the general features of these organs, and, indeed, were it not for them the singularly oblique attachment of the stem to the margin of the umbella would readily escape casual observation. They produce the effect of a striation (*figs.* 23, 25) on the surface in the same way that the ridges of the opsomyoplax appear like striæ in the umbella (¶ 81). By following these striations in their course from the marginal band (*fig.* 25, m^1) outwardly it will be noticed that they converge considerably, so as to form a sort of isthmus (m^5) directly opposite an anchor. Here the striæ are parallel for a short distance and then diverge as they run out toward the ledge (β^1) above mentioned (¶ 104). The divergence grows stronger as they proceed, and gradually those along the borders of the isthmus pass obliquely around the neck (*fig.* 23, α^1) in two opposite directions, following the edge of the ledge, until they meet on the distal side, and then, like those nearer the middle of the isthmus, pass on directly to the ovate mass (α^3). Between these two extremes there are, of course, all possible grades of obliquity, and consequently the neck or stem appears as if it were twisted, when seen in profile (*fig.* 23). This portion of the anchor is very short, not more than one-half or two-thirds as long as it is broad. It is apparently longer, but that is because the ledge from the chondrophys sets it out from the umbellar margin, and, moreover, under a moderate magnifying power, it seems to form a part of it.

106. The ovate mass (α^3) is also the homologue of the shaft of a tentacle, but it is so disguised as to deceive and mislead the observer who is not familiar with its successive stages of development, and very naturally might induce one, in that case, to see more than a mere resemblance to the spheroidal tip of a tentacle, and set it down as a homologue with the latter. That would indeed be far from correct, as we shall now show by pointing out the remnants of what was once a distinct,

spherical, nematocystigerous tip to an equally well-proportioned shaft. If the broad median furrow (*fig.* 24, a^6) of the anterior face of the ovate mass, be followed outwardly toward the distal end, it will be noted that it gradually becomes less opaque than the area adjoining, and finally assumes a semi-transparent appearance for a short distance before it terminates. In the middle of this semi-transparent area (*fig.* 25, a^5) there is a dark spot, which some observers in their haste have mistaken for an opening, supposing the darkness to be the pigment mass lining the interior of the cavity of this body. So far, though, from being thus, the dark spot is not only the surface of a solid, but that solid is slightly elevated above the area in which it is set, as one may see by glancing along the furrow, when it will appear as a spheroidal mass (a^2) imbedded on the top of a low boss, or truncate cone. Here again we meet with the striæ noticed on the neck, but not so strongly marked, yet sufficiently distinct to be traced along the semi-transparent area and upon the boss to the margin of the spheroidal mass. We hardly need say that the latter is the homologue of the globose tips of the tentacles. In extremely old animals the boss, even, is obliterated, and the spheroid is sunken into the face of the semi-transparent area, but is still distinctly recognizable by the numerous nematocysts which are embedded in its substance (*fig.* 47, a^2). It is not then the globose tip of the tentacles that we find here metamorphosed into an immense ovate, swollen mass, but a part of the shaft lying intermediate between the base and the end of it.

107. Keeping in mind, now, that the stem is attached obliquely to the broader end of the ovate mass on its posterior side, and that the spheroidal tip has been found at its narrower, distal end, and on the *anterior* face, we are prepared to understand that this mass trends obliquely to the longer axis of the whole, *i. e.*, the shaft, and completely encircles it in the form of a thick, broad, ovate, pad-like ring. The breadth and depth of this mass is not altogether due to the thickness of the ovate ring, but is in part accounted for by the very considerable extent of the cavity (*fig.* 47, a^4) of this organ, occupying not less than one-third of its diameter. Like the tentacles, the anchors are capable of expansion and contraction, but not to as great a degree. In the common run of adult specimens they are slightly knobbed or have an undulating outline, but in the very old ones they are deeply puckered, as if shrivelled, reminding one of a dried prune or raisin. Their color and opacity are the result of the combination of two distinct sets of pigment matter; the one lying near the surface, constituting the large, dark nuclei of the cells of the outer wall, and the other seeming to form a layer on the interior face, but in reality embedded in the lining wall, occupying in it the place of nuclei of the cells. The adhesive vesicles (¶ 208, A) which are buried just beneath the exterior surface add a little to the opacity; but being colorless, they are not conspicuous, notwithstanding their large numbers.

108. It is no difficult matter to expose the entrance (*fig.* 45, a^5) to the cavity of the anchor and at the same time prove that it has, like the tentacles, an open communication with the wide chambers of the umbella. There are no intertentacular, internal lobules here to obscure the view, and if one wishes to verify, by the tactile method, what has been ascertained with the eye alone, it can be readily done by cutting and raising a flap of the anterior parietes of the umbella, so as to

expose the internal base of the organ in question. Then one may either look directly into the passage way, or, if there be any suspicion that it is closed by a transparent membrane, the head of a fine needle can be thrust into it. We have fully satisfied ourselves, by all of these methods, that there is here a direct, smooth, and widely open passage leading into the cavity, and that the latter is not subdivided in any way, but is tolerably uniform in its length and breadth. In the stem the passage has rather the character of a channel, and expands quite rapidly into a tolerably wide chamber (*fig.* 47, a^4) soon after it enters the ovate mass. The chamber occupies the middle third of the shorter diameter of the mass, and lies at about an equal distance from the external surface both at its sides and at its distal end, yet approximates rather more closely to the anterior face.

109. *The walls of the anchors* (*fig.* 47) are remarkable for their great thickness at nearly all points; and if there is any exception to this it is to be found in the region which is homologous to the thickest part of the tentacles. The process of development is just the reverse in the two organs; in the tentacles the whole tendency is to give the nematocystigerous tip a preponderance in point of size and in the thickness of its walls; whereas, in the anchors, the greater weight is thrown into the midregion of the shaft, both in reference to its general amplitude and the incrassation of the walls, whilst the nematocystigerous tip (a^2) is gradually reduced to comparative insignificance, a mere reminiscence of its type. It is remarkable that we should have in these organs a repetition of that singular irregularity in the thickness of the walls which is so prominent in and about the adhesive disk at the caudal end of the body. Here, as there, the peculiarity is confined to the two innermost layers.

110. The *outer wall* (*fig.* 47, n^2) is a direct continuation of the opsophragma of the umbella, but is much deeper than the latter over the greater part of the stem and ovate mass. On the anterior face of the stem there is very little, if any, difference, but upon passing around toward the posterior face, and outward also into the ovate mass, the wall thickens rapidly to triple, quadruple, and even sextuple the measure in the first place mentioned. There is considerable variation in thickness at diverse points, but it is quite systematic in this respect. Along the broad median furrow it is thinner than anywhere else on the ovate mass, not being more than two and a half to three times the depth on the stem, and even this proportion is lessened greatly in the semi-transparent area at its distal end, until it actually falls below what obtains on the umbella. In the remnant of the nematocystigerous tip (a^2) of the tentacle the wall rapidly thickens again to equal the greatest measurement along the proximal end of the furrow. Passing laterally, from the midline, around the mass, the depth increases gradually until it reaches the maximum, sextuple measurement mentioned above. Where the anterior and posterior parietes of the umbella meet, at the distal side of the base of the anchor, the outer wall thins abruptly just as it joins the ectophragma (*fig.* 63). The adhesive vesicles (*colletocysts*) which form the main characteristic of the functions of the anchor, notwithstanding their multitude, have nothing to do with increasing the thickness of the wall; they are merely superficial adjuncts to its mass, while the

long prismatic cells which extend through its whole depth are the prime, and only elements concerned.

111. *Anchor muscles* (*fig.* 47, m^3). The peculiar arrangement of the fibres of the muscles has already been indirectly described when tracing the course of the oblique striæ on the stem, and in the semi-transparent area (¶ 105). After stating that they are identical in character with those of the tentacles, we have very little more to add, and that is principally in regard to the thickness of the layer, if it may be so called. The fibres are not so widely separate as in the tentacles, and consequently approach, in their combination, more nearly to a continuous stratum. They certainly are much heavier, and wherever a section runs along a band, the muscle appears much thicker. The mode of its termination and intrusion (at k^1) between the approximated margins of the chondromyoplax (b^2) and chondrophys (c), at the distal side of the base of the anchor, is the same as that of the tentacles, in a general sense, but differs somewhat in the trend, since it does not lie so obliquely, but traverses the intervening space much more nearly at a right angle to the surfaces of these layers. Not alone, though, do we find this intervening muscular partition at the distal side; it is also to be traced all along the border of the ledge (*fig.* 25, β^1) of chondrophys which supports the stem, and thence inwardly, skirting the "isthmus" (¶ 105) of muscle which joins the marginal plicate band, and becomes continuous with the similar curtain which that band protrudes (¶ 82) between these gelatiniform layers, at all points of the periphery of the umbella.

112. *The chondromyoplax* (*fig.* 47, b^2) of the anchors exists in a far more bulky proportion than in any other region of the body, unless we consider that in the proboscis as its equal in this respect. It lies in exactly the same relation to the other walls as in the tentacles, but, unlike it, has but one regular face, the outer one, whilst the inner contour is constantly changing its direction, at one point running deeply into the gelatiniform mass, sometimes plunging almost through its thickness, and then retreating at an acute angle back to its former level. The acute angled sinuses, that are so prevalent in the section which we have illustrated, are the expressions of as many conical pits and lateral diverticuli. They are abundant in all parts of the colletocystigerous mass, but fail in its stem. Along the anterior side of the latter the chondromyoplax is only a little thicker than in the thinnest parts on the umbella. From this region it thickens rapidly, going in two directions, one around the stem, and the other directly out into the ovate mass. Within the latter its general depth, leaving out the points occupied by the conical pits, varies but little, and is about two-thirds that of the chondrophys (c), just behind this organ. At the distal side of the stem it is fully as thick as the edge of the chondrophys which lies next to it; or nearly three times its own measure at the anterior side of the stem. The mode of termination at this point is the same as along the umbellar margin (¶ 66), but it is not penetrated by ridges of the muscular layer as in the latter.

113. The *gastrophragma* (*fig.* 47, i^4) of the anchors is remarkable for its extreme thickness, and the singular character of the prismatic cells which compose it (see ¶ 211). Within the limits of the stem it is only a little thicker than in the broad cameræ of the umbella, but just as it enters the cavity of the ovate mass it rapidly

increases to its maximum depth, which is, on the average, fully, if not more than, one-half that of the chondromyoplax (b'). It is rather irregular and undulating on its inner free surface; and on its other face it varies exceedingly, according to the irregularities of the chondromyoplax; filling every conical pit and diverticulum of the latter as if it had been moulded upon it. The chief peculiarity of this layer rests in the histological elements, and to that section of the subject the reader must therefore turn for further information in regard to the more intimate structure of the organ.

§ 14. *The Caudal Adherent Disk* (*figs.* 17, 18, 19, 37, 46, 51, γ).

114. The place which this part of the body holds among the organs is not so much due to its being a distinct anatomical form, as to the fact that it is the basis of certain functions which it performs in common with the anchors. Still its construction is such that it is evidently something more than a mere caudal terminus. Whether we look at it as a means constructed and adapted to a certain end, or as a means which has found itself best fitted for the purpose to which it is now put, it matters not; creative ingenuity would appear just as potential in the one case as in the other. The simplicity and slight differentiation which the organ—if we may so call it—presents, renders it none the less capable of doing what it, ostensibly, is intended to do than if it were the most highly complicated of all the systems of the body. Differentiation does not necessarily tend to the better performance of any one duty, but to the separation of two or more functions which may have been confided to the care of some organically simple organ. Every physiologist knows that, although the nutritive system of the highly complicated vertebrate animal is subdivided into an intestinal tract, to break down the food, etc. etc., and a set of bloodvessels to carry the absorbed nourishment to the tissues, these tissues are no more faithfully and thoroughly supplied with nourishment than those of the simple Polyp whose general cavity is both a digestive system to prepare the food for absorption and a circulatory system to bring the assimilable matter into contact with the tissues.

115. A very slight modification of the form of the caudal shaft suffices to give it the appearance of an official character, although we can readily conceive that it could perform its present duty without its discal expansion. The comparative extent of adherent surface would be the only element concerned. A change from a truncate terminus to a rounded or pointed one would make a great deal of difference as to the nature of the substance adhered to, whether flat or irregular. This species always clings to flat surfaces; and, as it lives where the currents and wave action are very strong, its expanded disciform tail seems to be eminently adapted to increase its power of resisting the tractive force of the moving water. The principal modifications of the layers of the shaft in the formation of the adherent disk consist, in the first place, in a rather abrupt expansion of the whole, followed immediately by a sudden changing of the course of the outline to a direction at right angles to its previous trend; virtually truncating the caudal terminus. The corresponding internal changes are noticeable chiefly in the ectophragma (*fig.* 19, f^2)

and the muscular cords (*fig.* 46, *r*). In the former it consists in a thickening of its mass to double its measurement on the shaft, and the embedding of adhesive vesicles (colletocysts, *a*) just beneath its outer, free surface. These cysts are very numerous and tolerably well crowded all over the flat face of the disk, but do not extend forward beyond its edge. The sucker-like shape of this organ is not, therefore, indicative of a sucker-like function on its part, and the power of adhering to bodies by its mere edge confirms the most warrantable inference, that the cysts are the true organs of adhesion. Some minor modifications are yet to be mentioned; but as they are already described in previous paragraphs (54, 63) on the form of the peduncle they need not be repeated here. The same may be said in regard to the muscular cord, which is described in paragraphs 59 and 88, but we will draw attention to the position of the two main furrows which cross each other at right angles (*fig.* 18, γ^1) on the face of the disk, as corresponding to the line along which the muscular cords (*fig.* 19, r^1) run. These furrows are but continuations of the four which trend at equal distances apart (ninety degrees) along the shaft, opposite the muscles, toward the umbella, and become there slight depressions, opposite the partitions, extending to the periphery. The most obvious relation of the furrows to the muscles is one of cause and effect. The muscles must have a *point d'appui*, and the furrows are simply indicative of the line of traction, which is nearest to the point where the contractile force is least expanded. From these lines it diffuses systematically all over the body. The minor furrows (*fig.* 18) on the disk, anastomosing into a network, probably correspond to the greatly varying irregular thickness of the chondrophys (see ¶ 57, 58, 72), which tends to become bent and folded in the direction of the lines of the least rigidity when the muscles, which are embedded in it, are contracted. The same feature is observable in the highly muscular anchors, in which we have also described a great inequality and want of regularity in the depth of the chondromyoplax.

§ 15. *The Digitiform Bodies* (*Digituli*).

116. *Form* (*figs.* 47^a, 65, 80, 98, 99, 100, 101). Notwithstanding the apparent relation of the *digitiform bodies* to the reproductive organs they are preëminently allies of the exterior prehensile organs, and, therefore, are most fittingly described here, no matter in what connection or for what purpose they perform their duties. The position and form of these bodies have already (¶ 52) been described in a general way, but the peculiar features for which they are so eminently remarkable remain to be illustrated here. Their elongate lanceolate outline is only observable when the flattened sides (*figs.* 47^a, 65) are turned toward the observer. Seen thus they appear narrow at the base and gradually expand to about their midlength and then as gently taper to a rounded point. Viewed at right angles to this (*fig.* 98) they taper, from a slightly constricted neck, uniformly to the tip. The thickness, at the broadest part, is to the breadth as one is to four or five. Usually they are single, but occasionally two or even three have a common stem for a short distance (*fig.* 65), and these pass on separately with the same form as the single ones. They are capable of a great range and variety in form and proportions. At one time they

are very slender and extend far out of the mouth of the proboscis, and at another, they are shortened down to broad, ovate bodies with blunt tips, and more than usually convex sides, approximating to fusiform. As to flexibility they seem to be unlimited, and so in regard to plasticity; now coiling like a mass of suckers, in an apparently indissoluble tangle, or spreading laterally, and folding at the sides, assuming a deeply concavo-convex shape, as if a sac with a wide lateral aperture. In the latter condition they have a wonderful resemblance to the laterally opening genital sacs. We have illustrated the two, side by side, at the time when the *digituli* were in the sacciform attitude (*fig.* 80, η, s^1). It would be difficult to state precisely what their size is, still there is probably a limit to it. When they elongate they also become more slender, and when they shorten they also widen, at a corresponding rate. An average length is about equal to the greatest breadth of a triangular genital half, or half as long as a fully extended tentacle.

117. *Function.*—The flattened lanceolate form of these bodies is by no means independent of other characteristics, of which there are two principal ones. In the first place the broad faces are turned respectively toward and away from the proboscis, and in the second place, *that face which looks toward the proboscis is covered, except near the tip, with a dense layer of colletocysts* (*fig.* 98, A), *while the opposite face and the excepted part of the other side, are beset with nematocysts, and heavily clothed with vibratile cilia* (B, C). Between these two sets of organs there is a sharp line of demarcation, and evidently, from the nature of their constituents, devoted to quite diverse functions. The proximity of these bodies to the proboscis and their occasional protrusion from the mouth, conjoined with the presence of colletocysts and nematocysts, all tend to indicate their use as prehensile organs, either in the transfer of food inwardly, or in the removal of material, fecal matter, or perhaps eggs, from within outward. Their adhesive powers are great, and their urticating organs are numerous, and no doubt serve more efficiently than the tentacles to reduce the struggles of prey, shrimps and other animals, and bring them into manageable condition for being thrust into the lateral cameræ of the umbella.

118. *The Gastrophragma.*—The walls of the *digituli* are direct prolongations from the three innermost strata of the anterior umbellar parietes. The *gastrophragma* is doubled in thickness as it becomes the peripheral layers (*figs.* 98, 99, 100, i^{π}) of these bodies. Its inner as well as exterior outline is sharply defined, particularly on the side (A) facing toward the proboscis, because it is there composed almost entirely of colletocysts (*a*), with their dense, semi-opaque, granular contents. Toward the tip (C) its inner surface is rather irregular and somewhat thicker than elsewhere.

119. *The muscular layer* (*h*) is the only division of the *gastromyoplax* (or *oömyoplax*) which is not exclusively devoted to the genital saccules. It is very thin, almost filmy, scarcely measuring one-sixth the depth of the gastrophragma, and then only where it is thickened into ridges. The latter appear, with a low power, to be coarse longitudinal striæ, but a closer examination, with a higher amplification, proves them to be interrupted ridges (*fig.* 99, *h*), trending parallel-wise to the longitudinal axis of the *digitulus*, along the exterior surface of the

stratum. Their average distance apart is, as we may judge from the drawing, about equal to the measure of the thickness of the gastrophragma.

120. *The Chondromyoplax* (b^4, see also 196).—We have every reason to believe that the fibrous prolongations which traverse this mass are direct emanations from the muscular layer (h^1), and that the amorphous portions of the chondromyoplax constitute the interstitial cytoblastema. There can be no doubt that fibres do pervade this mass, and, from analogy—with facts which we have observed in regard to the development of the chondrophys in the young Lucernariæ, and other Acalephæ—we do not hesitate to judge that they are part and parcel with the muscular layer which lies on the surface. The *chondromyoplax* (b^4) and the *gastromyoplax* (h) are here but two subdivisions of one layer. In passing we would add that in the *digituli* of young Aurelia-medusids the subdivision is much less marked than here, in fact leaving no room to evade the conclusion which we have come to in the present case. If this be true here, it would seem, of necessity, to be so throughout the anterior parietes of the umbella, but the subdivision is more nearly complete than in the *digituli*, and there is a higher specialization of the muscular layer, as evinced by the systematically arranged ridges, which tends to indicate a separate function for each, the one contractile and the other simply *resilient*. In the Lucernariæ these functions incline to blend, as far as their areas of action are concerned, and in the medusoid of Aurelia they are completely intermingled in that respect. Although the *digituli* are, like the internal intertentacular lobules (¶ 103), prolonged from the circumoral parietes of the umbella, their internal arrangements are quite diverse from those of the latter; since in the former the fibrillæ run across the longer axis of the gelatiniform mass, and consequently at right angles to the trend of their homologues in the circumoral chondromyoplax. At the base of these organs the transition of the trend of their fibrillæ into that of the umbellar chondromyoplax is gradual, just as it is in the genital saccules, and likewise in the same manner. It should be noted, in particular, that not only do they traverse the gelatiniform mass at right angles to its longitudinal axis but that their trend is from one broad face of the *digituli* to the other (*fig.* 100, b^4).

121. *Résumé.*—The amount and diversity of differentiation in these bodies doubtless surpasses, by far, anything of the kind in the whole class of Acalephæ; at least it would seem so since some of the highest forms which we have examined fall short in this respect. This tendency to outstrip its allies in special points, while failing to equal them in other respects, is everywhere characteristic of the comprehensive types. Among the Selachians we find the sharks imitating the placentation of the Mammalia, in this respect, therefore, rising above Reptilia and Aves. They doubtless surpass the Teliosts in every respect, except in the skeleton, and they fall short there only in the lack of hardness of the bone, but rise far above them in the conformation and differentiation of that system. In the Annelida a complete sanguineous circulation, but without distinct walls, is the premonition of a more fully developed system in the Arachnida; but this is almost lost in the perisplanchnic diffuseness of the hexapod Insecta. But, if Blanchard be right, the peritracheal circulation reproduces what is lost, in another, and

perhaps higher form, the blood going to the respiratory surfaces in distinct tubes, after the manner of the Vertebrata. Again, and finally, there are the Cystideans, prototypes of the Holothuria Apoda, and, if we mistake not, the genuine progenitors of Holothuria, exhibiting, like the highest of the latter, the clearest bilaterality and a strong reduction or suppression of the dorso-ventral repetition of parts. Their sedentary condition and a certain want of regularity and definiteness in the arrangement of their plates, are indicative of their inferiority, at least in the latter respects, to those Crinoids which have been disposed in systematic order. In our Lucernarian there is very little left, in point of inferiority, that debars it from taking the highest rank among Acalephæ. On a former occasion[1] we have placed the Lucernariæ—in a tabular view of their systematic position—as if intermediate in rank between the *Steganophthalmata* and the *Gymnophthalmata*. We think now that it would be doing better justice to arrange them almost on a level with the Steganophthalmata, overlapping their lower ranks, as it were, but failing to come up to the horizon of the topmost grades. But we are anticipating what we shall present in regard to this matter in another chapter (Part X), and we have yet in reserve more matter of equal interest to those who are curious to know what the status of our Acalephan subject may be. We have allowed ourselves to be diverted into this digression merely for the sake of laying heavier stress upon the quality and value of the singular diversities of differentiation in the *digituli*, while the mind is fresh from the work of investigation. Let us, therefore, recapitulate their prominent features in brief terms, and then proceed to the subject of the next section. In the first place they are lanceolate and *flat*. That leads to a survey of their position, in which we find their broad sides systematically facing toward and away from the proboscis. Again, these broad sides are diverse in character, the diversity of one kind always on the corresponding side: for instance, the one bearing the colletocysts facing toward the proboscis, and the other, covered by vibratile cilia and bearing nematocysts, facing in the opposite direction. Then there is the muscular layer more pointedly separated from the chondromyoplax than in the *digituli* of Aurelia, and doubtless others of the same order. And, finally, not only do the fibrillæ which traverse the chondromyoplax trend at right angles to those in the circumoral parietes, but they stand in very exact relations to the form of the digituli, trending directly from one broad face to the other, as if linking the layers of colletocysts and nematocysts to each other.

§ 16. *The Digestive System.*

122. *Forced Homologues.*—We have scarcely anything to do here in the way of a description of the digestive system, since nearly all that is concerned in it has been so thoroughly delineated from another, or several points of view as to render further illustration entirely superfluous. It will suffice, therefore, if we do no more than enumerate the several regions of the body which take part in the

[1] Lucernaria the Cœnotype, etc., ut sup., p. 22.

function in question; and this is absolutely necessary to a proper understanding of the limits of this system. That an Acaleph is possessed of a stomach or chymiferous cavity distinct from a general chyliferous chamber can only be asserted, even in part, by admitting, as we certainly do not, the Ctenophoræ into this class. That the Ctenophoræ have these two cavities is enough to rule them out of the circle within which the Strobiloida, Lucernariæ, and Hydroida are included. The peculiarity of Ctenophoræ approximates them, in this respect, *i. e.*, functionally, to the Polypi; and some naturalists have even gone so far as to assert that they belong there. We must confess that we do not see the faintest glimmer of a reason for so doing. Those who are accustomed to making forced homologues, by supposing this a little changed, and that a little something else, and the other not quite so much so, and everything else a tithe otherwise than what it really is, can easily twist the ideal Ctenophore completely out of its type, even, without knowing it, and with a logical (illogical) jump land in the midst of a totally different category of relations, and yet suppose that they have been standing still all the while.

123. *The Digestive Cavity Monomerous.*—The Lucernariæ also have been classed among the Polypi by all early observers, and even at this late day a place is claimed for them there by some naturalists. The character of their digestive system alone is enough to debar them from such an alliance. They challenge the closest homological comparison with the Acalephæ, as we have limited the class above, and no one who is at all familiar with their structure can fail to see their intimate relationship with them. The food does not digest in the proboscis (*fig.* 37, ρ), but is transferred to the post-buccal or central cavity (ψ^{c}), and even to the lateral cameræ (ψ^{1}) of the umbella. We have often noticed, in the latter place in particular, quite large shrimps undergoing the process of breaking down. There is, therefore, no subdivision of the digestive system into two parts, as in Polypi and Ctenophoræ. The food enters the mouth and glides through the proboscis (*fig.* 37, ρ) as if the latter were a mere conduit. It can scarcely be called anything else; assuredly it does not present the appearance of a digestive organ, for of all parts of the digestive system it is the least endowed with anything in the form of interstitial pigment or brown glandular-looking matter; and so far from being narrowed at its posterior end, it opens widely there, and passes insensibly into the general central cavity (ψ^{c}). We might even say that the digestive surface of the system is more diffuse than in the other two orders of Acalephæ; for in them the heavy, large masses of food cannot gain access to the lateral passages of the umbella, the so-called chymiferous tubes. There is, then, in the latter a closer approximation to that subdivision which obtains in Polypi than exists in the digestive system of Lucernariæ. Neither is there any dividing line, structurally speaking, that separates the four cameræ (τ^{3}) of the peduncle from the general cavity. There is a slight constriction of the breadth of space at their entrance (τ^{4}) and for a short distance posterior to that, but nothing that approaches to a valvular apparatus, nor anything of the sort. In *Calvadosia*, *Lucernaria*, and *Manania* the caudal chamber is single, and passes with widely spreading walls insensibly into the general umbellar cavity. There is also very little or no restriction to the entrance of the umbellar fluid into the tentacles and anchors of *Haliclystus*. If we look for accessory organs to the main digestive cavity, we meet with no glands, nor anything that approaches such a

structure; unless we hold the pigmental interstitial matter in that category, and even that is most abundant in the regions farthest removed from the centre of action, where it is supposed to be in greatest demand.

124. *Rank.*—In regard to the rank of the Lucernariæ, as affected by the conformation of the digestive system, the first thought would be to consider it as indicative of a low grade, because of its apparent diffuseness and want of subdivision into the central cavity and chymiferous tubes, as in the majority of the members of the other orders. There may be some truth in this, but it probably does not affect their status to such an extent as might be supposed. We have spoken of this diffuseness as *apparent*, and so we would seem to be warranted in doing if ve assume certain features in the other orders as *criteria;* for instance the digestive system of the highest of the Strobiloida, viz., Rhizostoma, Cyanea, and their immediate allies. We do not think that the Lucernariæ should be compared with the incipient *ephyra-stage* of the Strobiloida, because the latter happens to have broad pouch-like cameræ. There is a similarity but not a homology in their forms; but the latter becomes a reality, as far as their different ordinal relations will allow, when the circular tube is developed in the *ephyra.* But when that takes place the young creature is then on the way to a higher status, and that very process of going upward is one in which the digestive chambers are becoming more diffuse, less circumscribed, and tending to run all into one broad-spread cavity. This is the condition of things in the *Rhizostomidæ*, and *Cyaneæ*, while in the confessedly lower ranks of *Aureliæ* and *Pelagiæ* the diffuseness is least.

125. *Retrograde Metamorphosis.*—Perhaps all this may be explained on the score of a partial, digestive retrograde metamorphosis; and if so, it must be a tendency to a reversion to the simplicity of the *Scyphostoma.* But we are not willing to admit the verity of that commonly received phenomenon. So far from being a *retrograde* metamorphosis, we doubt very much if any case of the kind that ever came to hand was either more or less than a mere *mimetism.* This is our theory of the so-called retrograde metamorphosis. In every case which we have examined we found that the organization, instead of retracing its steps, actually took long strides forward. The nervous system of *Cirripedia* is a notable instance. The nervous system also of the *Acaridean Linguatula* is in advance of the same in its normally shaped colleagues; its vermiform outlines do not bear out the idea of the correspondence of form to internal structure. The so-called retrograde metamorphosis of the feet of the Loggerhead, and other marine turtles, from their embryonic, short, stumped, terrestrial form to the elongate, fin-like flapper, with completely inclosed digits, is a mere disguise; and curiously enough a *mimetism* of the limb of a higher type, a *Cetacean*, while it actually surpasses it in point of structural development; in fact retaining the principal elements of the limbs of its terrestrial congeners, the apparent retrocession being simply an external feature resulting from a mere elongation of the bones, and their adaptation by conjoined, consentaneous action to another kind of locomotion. And so we might go on with innumerable instances, but we have ventured to digress only far enough to illustrate our views in regard to the apparent inferiority of the digestive system of *Lucernariæ*, and do not wish to make an entire treatise upon the subject. If there is anything

meant by this apparent diffuseness it is a mere *mimetism*, while its simplicity is in all probability a form of unity and concentration. There is certainly a far less prevalent repetition of consimilar parts than in any of the *Strobiloida*. Were it not, indeed, for the strong indications of a special nervous system, as evinced by the highly developed optical apparatus in that order, there would be hardly anything left to rank it above the *Lucernariæ*.

126. Neither a *circulatory* nor a *respiratory system* can be said to exist, *per se*, in the Lucernariæ. The effect of these functions is produced, no doubt, at the same time that digestion takes place. The three are mere subdivisions of the process of nutrition and waste, according to modern theories of the physiology of the higher animals. Our Lucernarian stands in the same rank in regard to these subdivisions that the embryo vertebrate does, at the time when its nervous system is just dawning into existence, and the embryonic disk is nourished directly by the metamorphosis of the vitelline, subsidiary strata; when there are no vessels to carry material to the newly forming tissue, and no allantois to spread out these vessels over its surface, in closest proximity to the air.

§ 17. *Nervous System.*

127. *The Eye-spots* (*figs.* 26, 27, 32, 83, θ).—We are cognizant of the existence of a nervous system, or rather, we should say, of a nervous sense, by inference rather than by an actual view of anything tangible. Our deductions are drawn from two sources; the one comprises the action of the animal for a determinate end, and its irritability, and the other is represented by the *eye-spots*. The latter is the only legitimate basis upon which to found a nervous specialization, and that, even, is excessively meagre. We speak of these eye-spots because they occupy a position at the proximal side of the base of the anchors homologous with that in which a more highly developed and even well defined optical apparatus is to be found in other Acalephæ. In our Lucernarian it amounts to a mere accumulation of pigment, in unusual quantity, in a small circle, among the interstices of the prismatic cells of a specially thickened wall (*fig.* 83, *opsophragma*). The boss-like protuberance of the wall at these spots, conjoined with the conspicuous coloring matter imbedded in it down to half its depth, give it strong claims to some special functional status, or to a typical representation of what finds its full development in other Acalephs. The accumulation of pigment matter at any point concentrates light there rather than any other force capable of being taken note of by a nervous centre. Neither odor nor sound would be affected by it, nor does it seem possible that taste could be seated at a point so distant from the digestive system. That it is after all a mere foreshadowing, or a *mimetism*, of a more efficient organ of vision becomes strongly probable when we learn that these spots lose their distinctness, or disappear altogether, by the time the animal measures one-half an inch across the umbella. When the latter is about one-fifth of an inch across (*figs.* 26, 27, 28, 83) the spots have attained to their greatest definiteness, and from that period onward they gradually become obliterated; not so much, though, by fading out as by the increase of pigment all around them, until they lose their distinctness for want of contrast.

128. *Nervous System Formless.*—Beyond this indication of the eye-spots we have not discovered the least trace of anything that could be assigned to the nervous system. The remarkable regularity with which the cells of each wall of the body are disposed renders every step in a survey a positive advance in the knowledge of their histological relations; and we feel assured that no combination of strata and no assemblage of cells was ever more thoroughly studied, and we doubt if, but rarely, they ever received so much attention. If, then, there is a nervous system with a *form*, it must constitute a part of what we have described as the *muscular* system. This is a mere suggestion, and has no real basis, except that the muscles have a fibrous structure, and, as a bare possibility, might include among themselves nervous threads of a similar form. We know that it is no uncommon difficulty to determine, in some animals, what is nervous and what is tendinous or unstriped muscular fibre, but seldom do these barriers arise from their intermingling in one common *stratum*, or trending in parallel lines with each other. Much less do they originate from an impossibility to distinguish the one from the other, when they can be subjected to the highest powers of the microscope. This is our ground for assuring ourselves that there is no nervous system, having a *form*, intermingled with the muscular mass. That it has a potential existence, there can be no doubt, and that it can transfer sensations from the remotest points of the periphery of the body to its centre no one will deny upon seeing the tips of the tentacles convey some miniature victim to the mouth. Along what lines these sensations and volitions are propagated it is not possible to determine, but it seems to us more likely that interstitial *cytoblastema* should be the medium than that cells which are already appointed to the formation of a wall or a tissue should perform a double duty.

129. *Cytoblastema.*—In the lowest ranks of life, it is the amorphous cytoblastematous substance that prevails, that even constitutes the whole body, as every student of the lower Protozoa is well aware. The Amœba, Difflugia, in fact all Rhizopoda, are moving, sentient masses of *cytoblastema.* The velocity of retraction of a *pseudopodium* of a Rhizopod cannot be surpassed by the most highly developed muscle of a Vertebrate. The consciousness with which a Difflugia builds up its *test*, bearing each grain of sand to its place in the domicile with well-defined intent, is none the less an exhibition of the coursing of a nervous current through its homomorphous, cell-less mass, than is that of the Phryganean larva, with abundant striated muscles and sharply segregated nervous cord and fibres, building up its caddice-case, with all the ingenuity of a human basket maker. The cells which form the elements of a system, whether nervous or muscular, are not so much the necessary concomitants of the *function* which is to operate along certain lines, as the indicators of the outlines of the *differentiation* process—the guide posts, one might say, to prevent the nervous couriers from losing their way, and straying off, diffusing themselves in unknown regions of cytoblastema. The comparative diffuseness of the nervous centres in the middle ranks of Invertebrata prepares us for a still greater indefiniteness in the lowest grades; and we should not be surprised to hear of any one coming to the conclusion that in the latter there are no main centres of dispersion and reception of nervous power and sensation, but that they are as well displayed at one point in the body as at another, and from thence propagate

what they receive to other regions, with no more special adaptation for doing so than at any chance place.

130. *Nervous Centres.*—We are not willing, however, to accept this conclusion in its fullest sense, for we are too well aware of, and have said not a little in regard to, the relation of the nervous mass to the polar regions of the typical animal. Whatever the apparent diffuseness of the nervous centres may be, there can be no misapprehension as to their tendencies toward concentration in a certain region of the body. Any motion having a determinate end must be under the control of an influence which emanates from a well-defined *site*, to which all others, however diffuse, must stand in the relation of accessories, outlying posts, or frontier sentinels. The fact that all eggs, not excepting those of the lowest animals, exhibit a *polarity*, conjoined with the equally important fact that, at least in the middle and highest classes, these poles correspond respectively to the nervous and nutritive regions of the body, giving one the highest warrant for the assumption that even in the most inferior ranks there is a slight preponderance of the nervous elements, a tendency to centralize, in some one region rather than in another. The line of separation may be no more trenchant than that between the albuminous and oleaginous poles of the egg, and yet it will be enough to indicate an oppositeness of condition. And so we conclude, then, that, although the Lucernariæ have no visible nervous system, there is at least one or more regions of centralized power, from which nervous currents emanate and in which sensation leaves its impress.

131. *Homological Position.*—We cannot dismiss this subject without drawing particular attention to the homological position of the eye-spots, and thence to their significance as indicators of a specialization of the nervous system in reference to their function. They stand respectively, four opposite the flanks of the proboscis, and four opposite the angles of that organ. They are also subterminal, *i. e.*, not at the distal end of the tentacle (anchor), but at its base, or, more properly, where the base joins the umbella. By their swollen, boss-like character they remind one of incipient tentacles, springing up close to the next older that preceded them. They are then probably to be set down as rudimentary oculiferous tentacles situated within the line along which the anchors are disposed. Now in all Acalephæ the eye, so called, stands in close proximity to the margin of the umbella, and always in connection with its circumoral parietes. The Charybdeidæ are not even an exception to this, nor the Æginidæ; notwithstanding the ocular peduncle projects from the aboral side, its base is attached to the circumoral face. Rarely it lies on the distal side of the base of the tentacles, as in the medusoid of Coryne, but most frequently on the proximal side, as in Bougainvillia, Eucopidæ, etc. In the highest of the Hydroida (Tiaropsis, and the like), it is totally disjoined from the tentacles, but still is within, and not on, the line along which the latter are arranged. In the Strobiloida—whose optical apparatus is far more highly developed than in Tiaropsis and others of the superior ranks of Hydroida—the eye is borne on the end of a cylindrical, tentacle-like peduncle, and yet it is never marginal, but submarginal. It lies in a different line from the tentacles, whether the latter be strictly marginal, as in Aurelia, or submarginal, as in Cyanea. All of these correspondences form the thread which guides one from the lower depths of ocular

development, among the pigment spots of the Corynidæ, up to the unmistakably refracting, and, we doubt not, image-forming, plano-convex lenses of Aurelia.[1] Now although we have never been able, after the most diligent search, to discover a trace of a nervous fibre in Aurelia, yet its optical apparatus is so undeniably an organ of vision that a special nervous localization seems inevitable. Unfortunately for our wishes, Aurelia does not stand so high among the members of its grand division as to be subjected to that kind of differentiation which segregates the nervous matter from the surrounding mass and puts the cell-mark upon it. If then Aurelia fails in this respect, what can we expect to find in Lucernariæ, with their ill-defined eye-spots, but a far less developed nervous system, and still more diffused and undefined areas of nervous power?

§ 18. *The Reproductive System.*

132. *Differentiation.*—Of the two main points of difference between the Lucernariæ and the Strobiloida, the character of the reproductive system is scarcely second in importance. It is, beyond all question, unparalleled in concentration and differentiation, and is *unique* in design. But, as if these were not enough, there is added to one form of specialization another none the less marked, and certainly more conspicuous, in a total separation of the reproductive *stroma* from the mass of the umbellar parietes. The strata which inclose the eggs or spermatozoa have no part in forming the bulk of the umbella; they are *mere appendages* moulded into the form of globular sacs, and attached in the same way as the *digituli* to the circumoral face.

133. In the Strobiloida the reproductive material is imbedded in the general mass which forms the parietes of the umbella. The region of their genital organs, it is true, is specialized after a certain model, but it does not make it any the less a part and parcel of the boundary-wall of the general cavity of the body. We wish it to be clearly understood here that, when speaking of the Strobiloida, we do not include the Charybdeidæ in that order. Where the latter belong, in our opinion, may be found in the chapter (Part XI) on their morphology and in the one devoted to ordinal characters (Chapter XIII).

134. *The sexes* of the Lucernariæ are separate, but the structure of the saccules of both is identical. In description of the topographical position and the homological relations of the various organs to each other and to certain parts of the body, we have given all the general information that is necessary to a perfect understanding of the site of the reproductive system (¶ 50), its general outlines, appendages (¶ 52), arrangement, and relative age of the saccules (¶ 51). The structure, shape, and peculiar position of these organs remain yet to be given in detail.

135. *Structure of Saccules.*—In a previous paragraph (116) of the section on the *digituli*, we have described a singular attitude which these bodies sometimes assume, simulating the form of a sac with a broad spread mouth opening at the side

[1] See our description and illustration of this apparatus in the Contributions, Nat. Hist. N. Am. of L. Agassiz, Vol. III, Pl. XI^b, and Vol. IV, p. 41.

instead of at the end, by drawing the edges and ends of the digitulus together toward one side, so as to inclose a hollow space. The genital saccules (*figs.* 54, 61, 62, 74–77, 98, *s*, s^1, *s'*) are permanent embodiments of this configuration, but carried to a much higher degree of development. They are, in the strictest sense, *hollow* spheroidal saccules, and not mere solid globular masses of tissue and reproductive material, and are attached by a short, thick neck to the inner face of the circumoral parietes (*fig.* 54, ζ). They are totally disconnected from each other, but usually are so crowded that their peripheries come in contact and mutually mould themselves into polygonal shapes. On this account their appearance, from the exterior (*fig.* 37), is like a mosaic pavement. The oldest are considerably larger than the globular tips of the tentacles. In a full grown saccule the middle third of the diameter is a spherical chamber (s^1), which has its exit through an aperture (s^5) in the side of the neck. This aperture is as singularly marked in its position as the saccule is in general conformation, for it invariably faces away from the nearest umbellar partition in the direction of the older side of a genital half, and obliquely towards the proboscis. We are reminded here of the singular position of the flattened sides of the *digituli* (*fig.* 98, A, B), which we have taken note of in a former paragraph (117), seeming to show a relationship something more real than that of mere proximity. The component elements of the walls are also disposed very much after the manner of those of *digituli.* There is one-half, the exterior (*fig.* 74, i^1), of a saccule covered by vibratile cilia, but there are no nematocysts, and the other or inner side, instead of colletocysts (208, A), bears a bed of eggs (*fig.* 74, *g*), or spermatozoa (*figs.* 75, 76), sunken in pouches (s^1) formed by folds of the lining wall. Between these two walls the fibrillæ of the *chondromyoplax* (b^1) trend perpendicularly to its surfaces, but terminate against an underlying muscular stratum. There is from one hundred and thirty to one hundred and fifty saccules in each triangular genital half.

136. *The Walls and Layers* have very little to distinguish them in their cellular constituents, or other histological elements, from those of the circumoral parietes, to which the saccules are attached; but they differ widely in their conformation, and in the substances which they inclose. The outer wall (*oöphragma*, i^1) is a direct continuation of the *gastrophragma* (*i*), and has the same general characters, cellular composition, and covering of vibratile cilia as the latter, and is spread over the surface of the saccule quite uniformly and smoothly. At the mouth (s^6) of the saccule a rapid change takes place in the *oöphragma*, not only in its disposition but also in its cellular structure. Regarding the latter feature first, we will state that the cells (*fig.* 78, *i*) of the interior wall lose the prismatic shape of those of the exterior, and become more or less irregularly oval and flattened, but still retain their relative position in a single layer, although overlapping each other more or less.

137. *The Egg-Follicles of the Saccules.*—As for the lining wall (*figs.* 74, 77, *i*) in its totality, it is so disposed about the central chambers (s^1) as to render it one of the most conspicuous and important elements among the several peculiar differentiations which distinguish the Lucernariæ from all other orders of Acalephæ. It is *par excellence* the egg-bearing layer, *oöphragma*, since it immediately incloses the reproductive material in special *pouches* (s^2) which are formed by an inversion of

the wall upon itself. Each pouch or follicle contains either a certain amount of spermatogenous material (*figs.* 75, 76), or one, two, or three eggs (*fig.* 74, *g*), according to whether the individual is male or female. The follicles crowd closely upon each other, and all open into the central chamber. At the appointed time, when the eggs or spermatozoa are ripe, they are discharged from the mouths of the pouches into the general chamber (s^1) of the saccule, and thence pass outward, through the lateral aperture (s^0) in the neck, into the broad cameræ of the umbella. A full description of the eggs and spermatozoa may be found in the chapter on Embryology. As well as we can make out, there are from one hundred to one hundred and twenty-five pouches in a fully developed saccule. Their mouths are closed until near the time for the extrusion of their contents, and then, especially in the males, they are rather wide open. The space between the central chamber and the outer wall is almost entirely filled by the follicles and their contents, but what is left is occupied by the muscular layer (*öomyoplax*) and the *chondromyoplax* (b^3). The *oömyoplax* envelops the pouches like a *stroma*, and it might not inaptly be compared to that, and the *oöphragma* to a *tunica granulosa*. The fibrillæ of the *chondromyoplax* are arranged with tolerable regularity in the region of the neck, stretching directly from the outer to the inner fold of the wall of the saccule; but where they mingle with the pouches they form a sort of irregular mesh or network, and are not to be distinguished positively from the fibres of the muscular layer. This only serves to confirm us in the belief that all those fibrillæ which traverse the chondromyoplax in any part of the body are prolongations from the muscular layer, although we would not claim that they are identical with the muscular fibrillæ, but rather a prolongation of connective tissue. After the discharge of their contents the saccules collapse and shrivel to two-thirds or even one-half their former size, and the follicles gape widely and assume irregular shapes (*fig.* 77), while the fibrillæ of the chondromyoplax appear to be torn or more irregular than ever. An empty follicle (*fig.* 79) seems to be dotted all over its outer surface, but if examined by a profile view these dots turn out to be the broken and retracted fibrillæ of the chondromyoplax.

138. *Genitalia of Strobiloida.*—This investigation reveals to us here the fact that there is a double differentiation in the reproductive organs, which, when contrasted with the condition of the homologous organs in the Strobiloida, assumes the highest morphological importance. We do not intend to discuss the matter at this point, but will merely state the significant facts, that not only, as mentioned above (¶ 132, 133), do the genitalia of the Strobiloida form a continuous part of the umbellar parietes, but the eggs are simply immersed in the *chondromyoplax*, close to, and partly imbedded in, the *opsomyoplax*, *i. e.*, just beneath the exterior wall of the circumoral area. In the males the spermatogenous material lies in hollows in the same layer as do the eggs in the female, but a sort of follicle is formed about them by a superabundant gathering of fibrillæ which are prolonged principally from the *opsomyoplax*. This is their nearest approach to a true follicle that we have met with. The walls, strictly speaking, have nothing to do with it. We shall dwell at length on this point in the chapter (Part XI) assigned to the anatomy and morphology of Aurelia, and need not, therefore, proceed to further

details in this place. Frequently, if not always, the spermatozoa escape *through the opsophragma* directly into the outer world,[1] a thing impossible in Lucernariæ, since the genitalia have no connection with the two outer layers.

139. The *digitiform bodies* (*digituli*, ¶ 116) demand notice in this connection, not so much from any functional relation which they possess, as from their homological position when contrasted with the site of similar organs in the Strobiloida. It may fairly be questioned whether their *proximity* to the genitalia has any reference to their functions in connection with those organs, or whether they are there merely as the result of carrying out a certain architectural design. In some of the Charybdeidæ, as we learn through a letter[2] from Fritz Muller, "The digitiform bodies . . . in *Tamoya* are completely separated from the genitalia, and are to be found within the common *atrium* of the digestive chambers." This, we observe, is particularly noticeable in *Tamoya quadrumana*,[3] where the *digituli* lie in semicircles directly opposite the partitions of the umbella, but completely within the main central chamber. Their proximity to the genitalia is lessened considerably when compared with the closer connection of those in the true Strobiloida, but their relative position, as regards the prime vertical and horizontal planes of the body, and in reference to the genital organs and to the sides of the proboscis is not altered in the least, the architectural plan remaining the same. Notwithstanding, therefore, their apparent functional connection with the reproductive organs in almost all those Acalephæ which possess them, their true relations are evidently with the prehensile organs of the exterior, and we have, consequently, described them in that light, in a previous section (§ 15, p. 57). This does not affect their topographical homologies in the least, but, if anything, serves to disconnect them from that false estimate which gives more weight to anatomical structure and functional identities, than to morphological and homological relations, in determining the classificatory alliances of Acalephæ. To describe the *digituli* in connection with the *genitalia*, solely because of their proximity to them, would be about as reasonable as to include the hind legs of Marsupialia in the category of reproductive organs, because they happen to be the nearest appendages, and, in part, help to support the *marsupium*.

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[1] See Lucernaria the Cœnotype, etc., ut sup.

[2] Dated "January 1, 1865, Desterro, Brazil."

[3] Since Milne Edwards has corrected (see *Leçons Physiol.*, vol. iii, p. 56) his mistake in regard to the chymiferous canals of Charybdea, and has shown that what he formerly considered as such are the partitions of the umbella, and what once seemed to be solid intervening masses are broad tubes, or *cameræ*, alternating with the partitions, it becomes clear that the *Tamoya haplonema* of F. Muller is a *Charybdea*, and the *T. quadrumana*, F. Muller, remains the true representative type of the genus *Tamoya*, while the *Chiropsalmus*, Agassiz, founded on this species, becomes a synonym.

CHAPTER VI.

EMBRYOLOGY.

§ 19. *The Egg and the Spermatozoa.*

140. *The Egg.* (Pl. IX, *fig.* 108).—If it be taken for granted that all the illustrations of the eggs of diverse animals are full and faithful representations of their structure, then the one which we now offer for the consideration of naturalists is fully as complicated as any that exists. This, however, we are not at all willing to believe, for we have had such glimpses of what may be learned by the use of the microscope of the present day, as lead us to avow emphatically, and without fear of disproof hereafter, that the structure of the egg, as described and illustrated in various works, is useless, except in the most general way. What we want is an exhaustive comparative study of the development and anatomy of the *ovum* from its inception in the *cytoblastemon* of the ovary, through all its phases, up to the period when it is fecundated and passes on to its second stage. Such a series, for even any one species, does not exist in all our works and papers upon embryology. The labor is too hard to tempt any one of ordinary strength and patience. The single figure on our plate represents a fully developed egg of *Halictystus auricula*, as seen in profile. It was difficult to persuade ourselves, at first, that the egg of so lowly an animal could be so highly organized; we suspected some mistake; yet repeated observations only led to the same result; and we therefore present it here as an isolated fact, but with the remark that, as far as it goes, *i. e.*, as a representation of the consummation of one stage in the life of the animal, it is as full in detail and physiognomy as the best lenses of the time enabled us to make out. The albuminous and oleaginous poles are segregated with remarkable distinctness. The former or *germinal vesicle* (*gv*) occupies a pretty large proportion of the space embraced by the vitelline membrane, and lies close to the inner surface of the latter. The rest of the mass consists of the oleaginous material or *vitellus* (*vi*).

141. *The Vitellus.*—The form of the egg is an irregular oval, and its mass is more or less flattened by mutual pressure arising from the crowded state of these bodies in the saccule. It measures about $\frac{1}{750}$ of an inch in length. As many as three have been found in one of the pouches of a saccule. The *vitelline sac* (*vs*) is very thin, but is easily distinguished from the surface of the yolk on account of the peculiar structure of the latter, and presents sharp smooth exterior and interior surfaces. Its thickness is about $\frac{1}{25000}$ of an inch, and it appears to be homogeneous in texture throughout—a perfectly structureless, colorless membrane. *The yolk* (*vi*) has all the appearance of passing through the process of segmentation, but the presence of the sharply defined germinal vesicle and macula warns us against

accepting that view of it. Its whole mass is made up of colorless, minute granular matter shaped into spherical conglomerations which are packed so closely together as to leave no apparent space between them. This is all so transparent as to readily escape casual observation with direct illumination, and one might be led to refer the spheres to the *lumen* of granules out of the focus of the lens. A careful appliance of the light and the proper adjustments will bring out these features as strongly as we have represented them. There being no smooth, uniform surface to the yolk, but a series of irregular, rounded projections, there is no universal, continuous line of contact between it and the vitelline membrane, and consequently the inner surface of the latter stands out sharply and clearly. The diameter of the spherical conglomeration is from one-fourth to one-third that of the germinal vesicle. We are so surprised at this strange structure that we naturally seek to explain it by supposing the spherules to be the granular contents of cells, but that idea we are obliged to resign, for after the most careful search we have failed to detect the faintest trace of a wall about the globules.

142. *The germinative vesicle* (*gv*) is not much less than one-half the shorter diameter of the egg. In shape it varies from spherical to broadly oval or spheroidal, perhaps owing to the mutual pressure of the eggs. It is perfectly clear, and free from granules, and contains a large *macula* or *vesicula Wagneri* (*wv*). The contents of the latter are even less refractive than that of the germinal vesicle, and both are so in a very low degree. The wall of the germinal vesicle is excessively thin, appearing like a mere film under a magnifying power of five hundred diameters, and consequently its contents seem to be in a hollow space excavated in the side of the yolk.

143. *The Egg is an organized being.*—There is here, in the singular relations and form of the constituents of the yolk, in its stability and evidently organized condition, the very reverse of an unstable, simply fluid state. We have for a number of years argued that the yolk of the egg of all animals is not a homogeneous, homomorphous, mere fluid contents of a sac, stored as if in a reservoir for future elaboration, but, on the contrary, is an organized aggregation of matter under the influence of certain forces of a vital nature, which direct the laying down of its parts in definite places and in certain forms, always retaining them there from the very beginning of the development of the egg. Embryologists have frequently noted the precision and systematic order with which the contents of an egg are disposed, but they have invariably failed to recognize the organized character of the different regions and their distinct relations to each other, and to the changes which are to take place in the future. We need but refer to the eggs of birds to prove that the *ovum* is so far organized as to be inherently self-sustaining, existing in a low state of vitality for a comparatively indefinite length of time, waiting for the coming of such circumstances—either belonging to the parent or arising from purely physical sources—as shall cause it to develop to a higher phase.

We are well aware of the fact that some embryologists claim that the embryo always develops in the region where the germinal vesicle lies, and that the yolk is drawn into the body as if it were a mere supply of crude nourishment, but we do not know that any one but ourselves has promulgated the idea that the germinal vesicle and the yolk form an organized whole, the *animal-egg*, representing, in its lowest condition, the *animal* and the *vegetative* compound which we call a *zoön.*

144. The fact that in some animals, *e. g.*, the Vermes, Nematoda, and Trematoda, the germinal vesicle originates in a separate division of the ovary from that in which the yolk is developed, does not invalidate our theory, but, on the contrary, tends to sustain it. The ovarian *cytoblastemon* furnishes the material to start with, in any case; the albuminous substance on the one hand and the oleaginous on the other, and it is only a question of degree whether these two elements are brought together particle by particle and then each develops its peculiarities by consentaneous action in time and place, or each masses its atoms in a separate division of the ovary and elaborates its characteristic qualities there, and then are united into one mass. In either of these two extreme cases, the moment the particles of albumen and oleaginous matter come together they assume certain relations which we have indicated by the term *polarity*, and that is the beginning of the *animal egg*. The direct connection of the polarity of the so-called egg with the polarity of the later stages of the animal offers unmistakable evidence that the first stage, *i. e.*, the *egg-stage*, is not to be separated from the second any more than the second should be from the third. *All* are parts of what are necessary to make up the life of the *animal*. Each stage has its functions, the egg-stage has its, and so has old age; and the first should no more be separated from the second or third stage, because its functions are not identical with theirs, than the last, or old age should be, because it fails in some of the offices of the one previous to it.

145. *The Spermatozoa* (Pl. XI, *figs.* 130, 131, 132).—The general outline of the body is that of a cone which is twice as high as it is broad at its base. The interior is perfectly homogeneous and colorless. It is not a fixed, rigid attitude that we observe here, but one that varies considerably, especially about the apex of the cone. At the latter point we find the body continued into two excessively delicate filaments which are six or seven times longer than itself. These filaments are very severe tests of the powers of a microscope. They are much more slender than the so-called tail of the spermatozoön, and do not taper, but preserve the same diameter to their tips, where they terminate abruptly. Upon seeing these lash-like bodies coiling and twisting or swinging from side to side with every movement of the highly flexible, conical apex, we are reminded of certain flagellate infusoria. The broader end of the cone is indented where the tail is inserted. The tail is of enormous length, measuring at least twenty times that of the body. It does not taper, except for a short distance from its attachment.

§ 20. *A Young Haliclystus auricula, nearly $\frac{1}{16}$th of an inch in diameter* (Pl. X, *figs.* 121, 122 A. to D., 123).

146. Our records and illustrations of intermediate stages between the egg and the adult are intended not so much to furnish the details of changes which take place between youth and old age, as to explain the *morphogenic* phases through which the organs and certain regions of the body pass in order to reach their perfection. Their value, therefore, will be more appreciated upon contrasting them

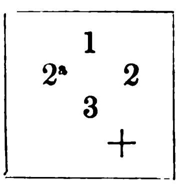
with the organization of other Acalephæ, than when considered separately. Instead, however, of taking up the history of the development of each organ, and following it through all its stages, as is the more common method in embryology, we think the interests of morphology will be subserved better if the morphogenic phases of all the various organs, at any one period, are exhibited in their fullest interdependence. We regret that we have failed to raise the young from the egg. There is an almost insuperable obstacle to doing so, because the parent does not thrive in confinement, and, again, the young are not pelagic, but follow the habits of the adult, and creep over the eel-grass from a very early period. The chances of finding them in the latter condition, therefore, are few, because they are so small. We have not succeeded in obtaining specimens but a little less than one-sixteenth of an inch in diameter across the umbella.

147. *General Features.*—The minutest individuals that we have met with, had already four or five tentacles in each group, and measured not quite *one-sixteenth* of an inch across the umbella. At this time not a trace of the reproductive organs is to be seen (*fig.* 121); but they appear soon after, as will be shown in the next set of phases that come under our notice. The specimens upon which our investigations were made were found about the middle of September, although we have discovered young of the same size two or three weeks earlier. The form of the umbella is so nearly circular that its slightly octangular contour scarcely attracts notice. The great prominence of the thickened, colletocystigerous portions of the anchors (*a*) renders them so conspicuous that they seem to be the true angles of the umbella. In profile, the body is much less cyathiform than in the adult, the umbella being so strongly flattened as to approximate quite closely to a T-form. The peduncle is proportionately very thick, so that, as a whole, the body is far less slender than the adult. As to colors, they vary as much as at any other time of life, but they are by no means so intense as at the latest periods.

148. *The proboscis* stands exactly in the same relative position, and is as distinctly four-sided as that of the adult, but is proportionally much thicker. Its butresses, however, are not so prominent. The main peculiarity of the interior of the umbella proper is the great thickness of the *partitions* (φ^2), and the very considerable breadth of the passages, between the four chambers, across the distal ends of the partitions. The *peduncular cameræ* are singular for their total separation from each other at their posterior ends, and they do not extend so far forward as in later periods. This, then, leaves the peduncle partially monocamerous, and leads one to suspect that, at a much earlier period, it is altogether so. This feature, no doubt, will serve among others as an embryonic *criterion* to determine the relative rank of the members of this order. The monocamerous genera *Lucernaria* and *Calvadosia*, from this point of view, rank lower than *Haliclystus*, and we would add that in other respects they confirm this testimony.

149. *The Tentacles* (*figs.* 121, 122, Nos. 1, 1ᵃ etc. to 4ᵃ).—At this period of development the prehensile organs are in such a condition as enables us, better than at any other time, to ascertain their *taxis* and mode of succession, as they increase in numbers. As may be judged from their relative position, there is every probability that at an earlier time but *one tentacle* terminated each corner of the

umbella; and since the anchors were then, doubtless, merely tentacles in form, there must have been sixteen tentacles standing isolatedly and equidistantly, forming a single row on the margin of the umbella. In other genera, like *Calvadosia* and *Lucernaria*, which have no anchors, there probably were, at a period corresponding to this, eight single tentacles at as many equidistant points. When describing these bodies in their adult state (¶ 89, 90), we pointed out the singular relation which each bunch bears to every other one in regard to its taxis and its general conformation. We find the same peculiarity here, and, moreover, an explanation of it is also presented to us by the mode of development of the tentacles. In the specimen under present consideration, there are only four tentacles in some of the bunches (*figs.* 121, A, A¹). Their relative position is made out at a glance, as it were; they evidently belong to no less than three parallel, concentric rows, the oldest standing on the distal side, and the youngest nearest to the proboscis. The following diagram, at the head of the next paragraph, and the figures (*figs.* 121, A, A¹, 122, A), in the plate, will serve to illustrate their taxis, as well as their succession in development.

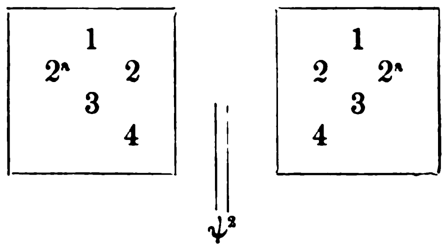


150. The figure 1 represents the primary tentacle, standing in the most distal row. That it is alone in the group is shown by the position of the two nearest (2 and 2ᵃ), as they not only lie nearer the axis of the body, but actually unite at their bases across the proximal side of number 1, and form the second row; and number 3, the smallest, stands still further in toward the proboscis, but opposite to 1, and alternating with 2 and 2ᵃ, and is the first of the third row.[1] Why we have numbered those of the second row 2 and 2ᵃ, instead of both alike,

[1] In N. Am. Acalephæ, Illust. Cat. Mus. Comp. Zool., by Alexander Agassiz, p. 63, fig. 90, there is an illustration of what purports to be a young *Haliclystus auricula*, "about one-tenth of an inch in height." It is slightly larger than the one which we are just now describing, and should, therefore, exhibit in the arrangement of its tentacles more of the characters of the adult. On the contrary, however, the author says, "the arrangement of the tentacles is totally different from that of the adult. They are as yet not arranged in clusters, but placed at regular intervals in one line on the edge of the disk." There is here such a marked discrepancy between the figure and the ostensible description that we are driven to suspect that the latter was intended for a totally different animal. So far from being in one line, the figure shows the single oldest tentacle overlapping the two of the next inner row, as it should be, when seen from the distal side of the group. Now, tentacles cannot well be "in one line," when of a number near together, as in the figure of the youngest group which is here described, two unite at their bases in front of the primary one, and separate it from the single one of the third inner row. Assuredly these are in a cluster. Again, we find another discrepancy between the figure and the description of our author in regard to the anchors, when he says, "No difference can at present be detected between the anchors and the tentacles of the disk," whereas the figure plainly shows the swollen colletocystigerous mass just below the tip of each organ, giving it a strongly humped appearance. The figure is in perfect accordance with our observations, but the description might apply to a *Carduella;* and singularly enough the author says, "The young Lucernaria is in this state a close representative of the genus *Carduella* which may possibly prove to be only the young of some European species." Now this looks very much as if the description was taken from a genuine Carduella, and, if so, we congratulate the discoverer, while by some inadvertence the wrong figure was supplied to illustrate it, representing the young of a genus belonging to a *different family;* but the figure is in the right place among the *Eleutherocarpidæ*, and the description, perhaps, should be among the *Cleistocarpidæ*.

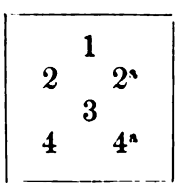
will become evident upon consulting the figure (*fig.* 122, B), which we shall use to illustrate the next step; we will merely state here that 2 begins to develop before 2^a, although in the same row. The + on the right of the diagram indicates where the next tentacle is to appear in the fourth row, and serves to set out the one-sidedness of the group, and its thread of development, in a stronger light.

150 (A). In other groups (*figs.* 121, B, B^1, B^2, B^3, 122, B) on the same indi-



vidual, there are five tentacles in four rows, the youngest of which is numbered 4, and the four others as in the previous group (A). It will be noticed, perhaps, that the succession of numbers is not alike, in point of position, in each bunch, for instance, in one group the numbers 1, 2, 4 lie on the left, as the observer faces the anterior end of the body, and in another bunch, 1, 2, 4 are on the right. Now, if the vertical plane of the body be assumed as a dividing line, we shall have these numbers in the two uppermost groups standing as if in antagonism to each other, the line of development in one trending in the opposite direction from that in the other; and so it is in the two lower groups; and likewise on the two sides of the horizontal plane. Or, if we look at them from another point of view, making the partitions (ψ^2) the dividing lines between the two groups nearest to them, we shall find the same antagonism, but with a reversal of the trend, so that 1, 2, 4 in each bunch lie next the partition. This gives us the clue to the one-sidedness of the groups, the preponderance, as we have noticed in the early part (§ 12) of this memoir, being on the side next the partition; for after the first tentacle was assigned its place, the second appeared on the side nearest the partition, and thenceforth threw the balance of age and size in that direction.

150 (B). Before any member of the fifth row begins to develop, another tentacle of the fourth row appears on the side most distant from the partition. It is numbered 4^a (*figs.* 121, C, C^1, 122, C). Thus far we have been dealing with the tentacles of one individual, and have found some slight variation in the number of these organs in different groups, but yet always preserving, in the order of their succession, a perfect symmetry relative to the partition. Their further development will be illustrated in the next section (§ 21).



151. The *size* of the largest tentacles in these young groups is much greater, in proportion to the magnitude of the body, than at maturity, as they measure in length from one-sixth to one-fourth the diameter of the umbella, *i. e.*, an average of one-fifth, but are very thick and stout, the diameter being at least one-fifth as great as the length. In the adult the proportion is as one is to twenty-five. As for the globose tip, it is quite distinct, but not remarkably prominent, and is about

one-third greater in diameter than that of the shaft, whereas in the adult it is three times that of the shaft. We shall not stop here to describe the mode of development of the nascent tentacle, as that will be done in a future paragraph, but it will not be amiss here to state simply that these organs originate as rounded papillæ, elongate into broad cylindrical shafts, and finally expand at the end into globose tips. The breadth of a group is so great as to leave only a very narrow interval between it and the anchors, so that we should say that, altogether, they occupy about two-fifths of the circumference of the umbella. If now we add the tentacle-like anchors, which cover another third of the circumference, we shall see that so little marginal space is left, and that, too, divided into no less than sixteen parts, that the umbella appears to be fringed by an almost continuous corona of tentacles.

152. *The Anchors* (*fig.* 121, $\propto$; 122, D; 123).—The distinctive characteristic of these organs is not so far advanced in development as to obscure the tentacular nature, and this is particularly noticeable on the proximal side, where scarcely a trace of the colletocystigerous mass is to be seen; and the walls are identical in their general features with those of the true tentacles. In point of size these bodies, exclusive of the colletocystigerous mass ($\propto^3$), are about equal, in length and breadth, to the tentacles. They have a similar thick shaft ($\propto^7$), and a well-defined globular tip ($\propto^2$). As regards their attitude, they are more rigid, and remain nearly fixed in a slightly bent form, inclined forward. The already large development of the outer wall, into a colletocystigerous cushion ($\propto^3$), gives the anchor a still more strongly bent figure, on the distal side, and in fact makes it appear as if it were humped. The greater portion of the colletocystigerous mass lies on the distal side of the organ, and extends a little more than two-thirds of the way to the globose tip. At the sides (*fig.* 121) it is nearly as thick as on the distal face, and thins out all around as it stretches toward the base and the proximal side of the shaft. Since, now, the tentacle-like portion has a tapering form, and expands at the base, passing gradually, as far as outline is concerned, into the umbellar margin, and the colletocystigerous layer thins out in the same direction, the tendencies of the two are mutually counteracted, and the combined parts present the appearance in front (*fig.* 121) of a broad projection with parallel sides, supporting a very short, globe-tipped tentacle in a sinus at its end.

152ª. *The Chondrophys* (*fig.* 123, *c*).—Of the gelatiniform layers we have but a word or two to say, and that only in reference to the chondrophys. The formation of this layer, in all probability, begins long before the time at which we have found it, as at this period it is already very thick in the umbella, at least five or six times thicker than the outer wall.

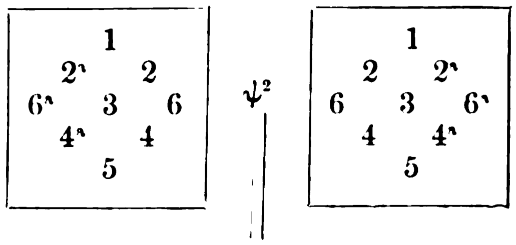
§ 21. *A Specimen $\frac{3}{32}$ of an inch across the Umbella* (Pl. II, *figs.* 20, 21; Pl. X, *figs.* 124 to 129).

153. At this age the chief point of interest centres in the incipient reproductive organs (*fig.* 20, λ). The stage previous to this might well be designated as the *proximo-ovuline stage*, and the one in which the reproductive organs originate, develop, and perform their functions might be denominated the *adult stage*. At

first thought it would seem advisable to recognize an intermediate phase between the latter and the former, to indicate the period when the reproductive organs are developing up to the fertilizable condition; but there is an insuperable objection to this mode of subdivision of ages, namely, there is no time, not even when the animal has reached extreme old age, in which some of the genital saccules are not originating and developing. If any one will turn to the description and figures of the adult organs (¶ 51), he will there learn that on one border of a genital-half the oldest saccules are invariably found, and that from that point onward toward the opposite side these saccules become gradually less in size and lower in the degree of development, until at the extreme border they are no further advanced than in the young individual now before us.

154. Specimens of the size mentioned above were found in the last week of September. The umbella (*fig.* 20) at last has a distinct octogonal outline, and the margin (ψ^3) between the groups of tentacles, is slightly retreating. In profile the body appears more strongly cyathiform than in the *proximo-ovuline* phase (§ 20), and the pedicle is more slender. Added to these we mention the increased length and greater slenderness of the tentacles as tending largely to give the body a more graceful appearance. At the same time their increased numbers render them more conspicuous, while the anchors are only a secondary feature in point of prominence. The peduncle, also, is more slender than in the last stage, and its adherent disk is a strongly marked expansion. There is nothing peculiar in the proboscis (ρ) to distinguish this phase; but we would call attention to the drawing for the sake of explaining away the apparently minute size of this organ. It happens to be represented when it was strongly contracted at its anterior end, and the mouth nearly closed. The object in presenting it in that state was to expose the proximal ends of the four umbellar partitions (ψ^2), and of the reproductive organs (χ). The muscular system of the umbella is sufficiently developed to be recognized readily, but is too faint to affect the general physiognomy of this region.

155. *The Tentacles.*—At this age we observe for the first time traces of the peculiar ranked arrangement, so characteristic of the full-grown forms. This is the result of the taxial relation under which the tentacles originate, and theoretically prevails in the group from its initiation; but it does not strike the attention of the observer until increased numbers add to the length of the ranks. In the last, or proximo-ovuline phase, we have noted as many as six tentacles in a group. In the specimen now under our eyes, there are no less than nine tentacles (*figs.* 20, 125,



126) in some bunches, and one or two more in the others (*fig.* 21). Next to 4ª of the last phase (§ 20) 5 succeeds and lies in line with 1 and 3, so that the members

of the middle rank would be designated by the numbers 1, 3, 5. The eighth tentacle is numbered 6, and is so placed as to alternate with 2 and 4, and presses against their bases. The ninth is numbered 6^a, and holds the same relation to 2^a and 4^a that 6 does to 2 and 4. As the numbers increase, the tendency is to widen the group, by the development of new tentacles in the neighborhood of the oldest. This is seen in the appearance of 6 and 6^a, so far away from 5, and so near to 2 and 2^a. We cannot say positively where the next that are to increase the lateral extension will appear, but we have good reason to think that they will arise alternate with 1 and 2 on one side, and 1 and 2^a on the other (see cut 4, p. 45). An inspection of the diagram (see cut No. 4) of the taxis of a full-grown group will assist us in this matter. It is plain enough here that the tentacles lying on each side of 1 must have originated where they stand, and, according to the method exhibited in the diagrams of young groups, after 2 and 2^a, and consequently on the distal side of the latter.

156. The relative age of the tentacles on each side of 1 is not to be seen in their proportional size; but if we follow the curved rank along the distal side of the group (see cut No. 2, p. 43), we shall find that, as we recede from 1, they decrease in magnitude regularly, until they attain a *minimum*, at the proximal side, in the last one at each side of the row. This would seem to show quite conclusively that there are two lines of progress in the development of the tentacles; the one trending centripetally, as indicated by the numbers 1, 3, 5, etc., and the other trending laterally on each side of 1, and following the margin of the umbella. That those in either of these *trends* succeed each other in one, two, three order is far from true; but that those in one trend alternate with those of the other trend in the time of their origin and rate of development is probably indisputable, judging from the diagrams of the taxial succession of the young groups. What *formula* expresses the taxis in the present case we do not pretend to have discovered, and we must leave it to the determination of more profound taxonomists than ourselves. The diagram of the youngest group (¶ 150) which we have met with would indicate the three ranked arrangement if applied to a plant, the formula of which is $\frac{1}{3}$. In the diagram of nine tentacles (¶ 155), this taxis seems to be carried out as far as the seventh (No. 5) tentacle; but the introduction of 6 and 6^a alternate with 2 and 4, and 2^a and 4^a destroys the continuity, and evidently introduces the element of another formula.

156*a*. From the manner in which the tentacles in the diagram (cut No. 4) of an adult group succeed each other, it is plain that the transverse rows should be numbered thus, row 1 = No. 1; row 2 = Nos. 2^a, 2; row 3 = Nos. 6^a, 3, 6; row 4 = Nos. 4^a, 4; row 5 = No. 5; row 6 = A^6, A^6; row 7 = B^7; row 8 = C^8, C^8, etc., to H^{12}, because, starting with No. 1, we saw in the young (§ 20) that 2^a, 2, developing next, united across the proximal side of 1, and formed row 2; and since 2^a, 2 separate 3 from 1, No. 3 must be in row 3. Then, again, since 4 , 4 stand in the same relation to 3 that 2^a, 2 do to 1, it follows that 4^a, 4 belong to the next row within 3, *i. e.*, to row 4; and so 5 succeeds in the next, or fifth row. Thus going inward toward the proximal side of the group, A^6, A^6 are in row 6, and B^7 in row 7, etc., etc., to H^{12}

Except in the case of 6ª, 6 we do not know how the above enumerated rows are extended on each side. It is plain that 6ª, 6 extend row 3 on each side, since they do not introduce a new row. Hence we infer that row 1 is extended by the development of the tentacles on each side of No. 1; and so with row 2ª, 2, and 3, etc. etc. In *Carduella* it appears that row 1 is extended so as to have at least half a dozen tentacles before row 2 begins, and that row 2 also extends considerably before row 3 commences. In *Halimocyathus*, the development is more rapid in the formation of new rows, contrasted with the lateral extension of the oldest rows in *Haliclystus*, as we have shown in our Prodromus (Journ. Boston Soc. Nat. Hist. 1863, p. 534).

157. The proportions of length and thickness of the oldest tentacles have changed considerably since the last phase, and they are much more slender in the present case, but yet quite heavy when contrasted with those of the full-grown animal. The prominence of the groups is due not alone to the length of the tentacles, but is increased considerably by the strong projection of the angles of the umbella. Taking this into account, and also the fact that the marginal interval between the groups and the anchors is much greater than in the last phase, we can readily understand why these two sets of prehensile organs do not seem to form a continuous row along the umbellar border.

158. *The anchors* (*fig.* 20, α). The tentacular origin of these bodies is still strongly hinted at, notwithstanding the greatly increased development of the colletocystigerous mass. The latter, when seen from in front, forms a Y-shaped figure about as long as wide, and bears the tentacle-like portion in the deep terminal sinus. Altogether about one-half of what was originally a tentacle still retains that form, while the basal half is disguised by the development of the colletocystigerous mass. One-third only, or a little less, of the intertentacular umbellar margin is occupied by the basal attachment of the anchor, leaving unoccupied, therefore, two-thirds of it as a pure border, unmodified by the lateral extension of the neighboring organs. This is, in a marked degree, a contrast with the corresponding space in the preovuline stage (§ 20), when the transition from the bases of the tentacles to those of the anchors was almost uninterrupted by a margin.

159. *The general cavity* is but slightly modified since the last stage, and that only in the umbella, where the incipient genitalia (λ) form slightly raised, elongate-oblong plateaus. Of course it will be understood that these plateaus are built up, as it were, by the closely juxtaposed, nascent genital saccules, eventually constituting a sort of pavement-work, as in the full-grown animal. The partitions (ψ^2) are as yet quite thick, and very conspicuous from without. They seem to have the full proximo-distal extent of those of the oldest individuals. Their diameter is increased, no doubt, largely by the great depth of the *gastrophragma* (¶ 75, 76), which is nearly or altogether as thick in the peduncle and umbella as at the bases of the tentacles or within them. The actual thickness of the gastrophragma is much greater in the umbella and peduncle than at the same points in full-grown bodies. The four *cameræ* (*fig.* 127, τ^3) of the peduncle, as yet, remain totally distinct from each other posteriorly. They lie much nearer the axis (*fig.* 128), and occupy a larger portion of the peduncle than in their maturity, by one-

third, at least, in lateral extent; but no more between the axis and the periphery. At the posterior end (*fig.* 127) they are still more expanded, indeed almost to double their diameter in front. In a transverse section (*fig.* 128) they present a broadly ovate outline, with the narrower end next the axis; or in the posterior region (*fig.* 127) they are approximately triangular.

160. *The Muscular System* (*figs.* 20, μ, 127, 128, *r*).—We have once before spoken of the muscles of the umbella (*fig.* 20, μ), and yet revert to them here in order to add that their presence is proved not only by their histological elements, but by the already well pronounced ridge-like incrassations which extend like the rods of a fan from the proboscis to the margin of the umbella. The marginal muscle is still inconspicuous, as far as external appearances would indicate its presence. The chief point of interest is in the *peduncular cords*. Viewed from without they might very naturally be mistaken for a second set of canals alternating with the true cameræ. They have, in reality, the form of a hollow cylinder, which is slit open along its whole length on the side facing the axis. In a transverse section (*fig.* 128, *r*) they appear like crescents, with the horns nearly in contact, imbedded in the chondrophys (c^1). At the posterior end the cylinder expands (*fig.* 127, *r*) a little and terminates abruptly, without sending off a process toward the axis, as is done in the later periods of life. The mass seems to be composed of minor cords placed side by side, so as to inclose, in a rough way, a space, which opens on one side, as mentioned above. This gives the muscle a longitudinally furrowed appearance, both without and within the cylinder. The deeper and more conspicuous furrows are evidently the spaces between the minor cords, and the smaller furrows are mere longitudinal depressions in the solid mass. If, now, we contrast these cylinders with the cords of a full grown individual (*fig.* 52, *r*), we shall find that the younger ones are proportionally a great deal larger, as any one may see at a glance, upon inspecting the transverse section of the peduncle of the animals at these two extreme ages, and comparing the cords with the cameræ (τ^3). Observe also the space which the former occupy between the latter, or between the axis and the periphery of the peduncle. Finally, we would draw attention to the peculiar relation of the interior of these muscular cylinders to the chondrophys. It would seem to be a law in the organization of these parts that the *chondrophys* shall form a surface of contact to every exposed part of the muscle, and, therefore, here in the young, even the interior face of the contractile cylinders abuts against the fibres of the chondrophys (c^1), the latter entering the cavity of the former through its longitudinal slit. These fibres have essentially the same arrangement throughout the peduncle as in the full grown body (¶ 198), but they are much fewer, and are less delicate.

160*a*. *The Chondrophys* (*figs.* 127, 128, c^1).—The great thickness of this layer in the peduncle at this period leads us to the conclusion that it was not much less in the previous phase, since in that it was very deep in the umbella. Its relation to the muscular cords has already been indicated with sufficient precision when describing these bodies, except so far as regards its histological, fibrous elements, and these will be treated in due time, in the chapters on the structure and development of the tissues (Chapter VII).

§ 22. *A Young Specimen* $\frac{1}{8}$ *of an inch across. Special Development of a Tentacle, a Colletocystophore, and a Genital Sac.* (Pl. III, *figs.* 29–33; Pl. V, *figs.* 58, 59; Pl. VII, *figs.* 67–73.)

161. This specimen exceeds the last more in size than in the degree of development of its organs, and we might, therefore, almost say that the following description is but a continuation of the previous one. Although only one-eighth of an inch across, the umbella seems broader because the tentacles are so conspicuous, and are longer and more slender than in the last stage. This will appear plain enough if we reflect that as the longest tentacles (*fig.* 33) are one-fortieth of an inch long, they extend the limits of the body one-twentieth ($\frac{2}{40}$); and as the umbella is one-eighth ($\frac{5}{40}$) of an inch across, the proportion of the latter to the augmentation by the tentacles will be as $\frac{5}{40}$ to $\frac{2}{40}$, or 5 to 2. In the full grown animal the proportion is as 4 to 2.

162. *The Tentacles.*—We have recorded, above, the relative length of the oldest tentacles of this specimen; and now propose to trace the development of these organs from their initial stage up to their full stature. The foundation of this investigation lies in the specimen before us, but the older stages are to be sought for in advanced animals, where the multiplicity of tentacles furnishes a more complete series than where there are only ten or a dozen of these organs in a group. In the first place we will recall the fact, already stated (¶ 93), that the youngest tentacles are always found on the proximal side of a group, and that the oldest lie next the boundary line between the circumoral and aboral faces of the umbella. The earliest trace of an incipient tentacle is exhibited by the appearance of numerous *nematocysts* (*fig.* 58, ϕ^2), collected in a closely crowded group very near the bases of the other tentacles. It is, therefore, evident that the globular, nematocystigerous tip, the prehensile region, *par excellence*, is the first to develop, and, as we shall see hereafter, to perform the duties assigned to the organ of which it forms a part. The shaft is merely the basis, the handle as it were, by which the instrument is moved from place to place. After this a rounded protuberance (*fig.* 59, ϕ^2) rises gradually above the circumjacent area, bearing on its summit the group of nematocysts just mentioned. A profile view of this bud discloses its relation to the walls of the body, and we find that from the beginning the whole depth of the circumoral face (ζ) is enlisted in the process, even to the innermost wall, the *gastrophragma* (i); for as the bud rises on the outer surface the inner wall also pushes outward with the others, and thus a hollow hernia is formed by the combined action of all. The elements concerned in this process are as follows, taking them in their order from without inward: first, the *opsophragma* (n), in which the nematocysts are imbedded; second, the *opsomyoplax* (m); third, a faint trace of the *chondromyoplax* (b); and fourth, the *gastrophragma* (i). The first, at the outset, is considerably thicker than in the adjacent parts. The second offers nothing remarkable. The third, from its peculiar relation to the second (see ¶ 65), is not to be separated from it by any trenchant line. The fourth is thicker than its homologue (i) in the umbella, but thinner than in the older tentacles next to it. From

the very beginning to the latest period of life there is always the same, unvarying, *single stratum* of cells in the *opsophragma* and the *gastrophragma*, no matter how great the changes they undergo in other respects.

163. The bud soon becomes a prominent feature by rising quite abruptly from its foundation. It does not, however, present any marked change in its constituent walls, nor in its proportion, except that it becomes distinctly cylindrical, until it is longer than it is broad, and then (*fig.* 54, A) it begins to expand more rapidly at the base and becomes pyriform. At no time does its interior (ϕ^3) cease to communicate openly with the general cavity of the body; nor is the passage-way into it flanked by intertentacular processes until it has advanced considerably beyond the mere bud-like stage. At the beginning of the *pyriform stage* (*fig.* 54, A) the outermost and innermost walls are a great deal thicker near the tip (ϕ^2) than at the base (ϕ^1) of the tentacle. The outer wall gradually thickens along the shaft until it becomes twice as deep in the region of the nematocysts as below. In the innermost wall the difference is not so great by one-half, nor is the transition so gradual, the thickening proceeding very rapidly where the opposite faces converge at the tip. The circumscription of the nematocystigerous area is not yot distinct, as we find the nematocysts extending down the shaft, in diminishing numbers. The myoplax and the chondromyoplax begin to be distinguishable as separate layers, but the latter is very thin, a mere film. It will be judged from these facts that the development of a tentacle is not a mere mechanical protrusion of the walls, stretching outward into finger-like processes and there fixing themselves. If it were so the already well developed chondromyoplax of the circumjacent area would be fully represented, and not obscurely merged into the myoplax. There is, however, one remarkable feature to be noted here, and that is, the bud is very nearly as broad as the bases of the oldest tentacles. This is not because the walls are as thick, but the cavity is much broader in proportion. On this account it is not an easy matter to determine the relative ages of those which stand intermediate between the pyriform stage and that in which the globose tip is distinctly marked out.

164. From this time onward the principal changes consist in the elongation of the shaft, and an increasing slenderness (*fig.* 34), while its innermost wall (*fig.* 48, i^2) and the chondromyoplax (b^1) thicken gradually, and diminish the diameter of the cavity. At the same time the nematocystigerous region (ϕ^2) increases very rapidly in depth, and its boundaries become insensibly more circumscribed, until by the time the tentacle has attained a length which is from ten to twelve times greater than the diameter of the shaft, it finally assumes a decidly globular form, and is separated from the shaft by a sharply defined line. The latter is particularly noticeable in the largest tentacles (*figs.* 54, 55) of full grown individuals, where it may be recognized as a narrow, light band, in reality a sharp constriction, at the line of junction between the shaft (ϕ^1) and the spheroid (ϕ^2). It is also observable in quite young tentacles (*fig.* 33, ϕ^4), but is far less conspicuous than in the oldest of these organs. The last noticeable change occurs after the tentacle is very nearly full grown, and then the spherical tip becomes depressed at the distal end and assumes a more or less oblate spheroidal figure (*figs.* 41, 42).

165. *The interior intertentacular processes* demand a little attention in this connection, since they are something more than mere intermediate areas between the tentacles. What their precise office is we do not even pretend to suggest, from the knowledge of any established facts; nor is it necessary that they should have any functional importance, notwithstanding their very marked features. They appear initially as simple, low, conical protrusions (*fig.* 58, π) from the areas between the adjacent bases of the tentacles. They are perfectly solid, and include only the gastrophragma and the chondromyoplax (b^{3}) within their limits; not differing, therefore, in this respect, from their full-grown condition (*fig.* 55, π). Their innermost wall, at this period, is very thick, fully equal to that of the tentacles. Eventually they become more prominent, and, at the same time, connect laterally with each other, forming a network of ridges. This occurs as early as when the umbella is no more than one-eighth of an inch in diameter, and the processes have a slightly pyriform shape. Finally they thicken largely toward the free end, by the enormous development of the chondromyoplax, and become as we have described them (¶ 103) in their full grown condition. During the gradual expansion of the chondromyoplax, the gastrophragma proceeds in the inverse way, and finally becomes excessively thin by the time the animal reaches maturity.

166. *The Anchors.*—By means of an arrest, or rather retardation, of development in one specimen, evidently arising from an injury to one side of the umbella, we are enabled to trace the process of the formation of the colletocystigerous layer, and to prove, beyond all demands for testimony, that the anchor originally has the proportions and structure of a tentacle. The character of the anchors in a normal condition is illustrated in a figure (*fig.* 32) which we shall describe presently; but we must go back now to a younger stage of these bodies, as exhibited by an anchor which has developed less rapidly than the others, belonging to the same individual. This example (*figs.* 30, 31) has all the appearances of a tentacle far advanced in development; the globose tip ($\propto^{2}$) abounds in nematocysts, and is sharply restricted from the shaft; the latter is four or five times longer than thick, and its muscles are so strongly developed as to appear like heavy ridges ($\propto^{1}, \propto^{7}$), as in a full grown, genuine tentacle. The only difference between the tentacle and the anchor is to be found in a slight thickening ($\propto^{3}$) of the outer wall of the latter over the middle third of the shaft, along the distal and lateral portions. This has an oval form, and is studded with *colletocysts*, scattered in an irregular manner, just beneath the surface. It is thickest on the distal side, and thins out at its edges, to the depth of the wall immediately about it. Its distinctness is due largely to the great development of pigment matter within the nuclei of the cells of the outer wall. There is nothing of the kind as yet on the proximal side, the wall retaining, up to this time, a purely tentacular character ($\propto^{5}$) from one end of the shaft to the other.

167. The next earliest stage after the one just described is to be found in the anchor of the youngest Lucernaria that has come under our notice, and described in a previous section (§ 20). In addition to what is there recorded we will make some further statements, principally in the way of comparison with the previous stage. The main point of difference lies in the relative thickness and extent of the colletocystic mass, which in the present instance (*fig.* 123, $\propto^{3}$) is considerably

greater in both respects, since it almost encircles the proximal as well as the distal and lateral faces, and also has such a strong development of its depth as to present a prominent hump on the distal side. We ought to mention, also, that the chondromyoplax (b^2) is a strongly marked layer in the colletocystic mass.

168. Returning, now, to the specimen from which we obtained the youngest anchors, we find, in a normal condition, (*fig.* 32) a phase slightly advanced beyond the last; differing principally in the increased relative shortness of the shaft, tending, as we shall see hereafter, to sink the globose tip into the colletocystic pad (α^3). There is no diminution, however, in the intensity of the tentacle characteristic; in fact, we might justly say that it is rather increased in some respects, for instance, by the greater sharpness of the line of demarcation between the shaft and the spheroidal tip, and particularly by the appearance of the narrow, elastic band at that point, so eminently conspicuous in tentacles far advanced in development. The physiognomy of the colletocystic mass does not vary from the youngest example, as regards its histological elements, but, as for its proportions as a whole, there is a sufficiently marked change to render a comparison of it with a fully-developed anchor facile enough to satisfy the most exacting criterion. Already the terminal portion of the shaft and the globose tip have the appearance of being appendages of the colletocystic pad, rather than the reverse. The dominant feature of the anchor is rapidly approaching the condition when it is the only one to be seen without a special search. We think this will be clear enough to any one who will take the trouble to glance over the following figures (*figs.* 81, 82, 83, 26, 27, 25), which are yet to be used to illustrate our subject. We have yet to mention one other feature of progress in the case before us, and that is, the strong bulge (*fig.* 32, α^6) of the proximal face of the shaft, opposite the area covered by the pad. It is not yet encroached upon by the colletocystic mass, but yet it may be forced out into a prominence by the gradual enlargement of the lateral extent and depth of that mass, rather than by any inherent property. The cavity of this organ, however, would seem to militate in favor of the latter view, for we learn, upon close scrutiny, that the lining wall—*gastrophragma*—bulges and thickens a little also, in the same region, so as to trend parallel with the outer wall. This could hardly be produced by any influence that the colletocystic mass might bring to bear, especially as it is the initiatory step in the formation of the larger freed chamber of the full grown organ. The chondromyoplax plays a much more conspicuous part here than in the oldest tentacles of this individual, occupying at least three-fifths of the depth of all the combined layers.

169. In order to make the developmental process of the anchors as clear as possible, it seems advisable to describe it in a continued succession of sketches, and we shall, therefore, draw into the limits of this section all the phases that we possess, in the form of illustrations. The next one that we shall take up for consideration (*figs.* 81, 82, 83) has lost a large part of the shaft of the tentacular form, and the globose tip (α^2) stands out like a high knob on the oblique face of the colletocystic pad (α^3.) It belongs to a specimen which measures slightly less than one-fifth of an inch across the umbella (*fig.* 84). The pad (α^3) itself extends, on the distal side, downward to the base of the original shaft, as in the

full grown organ, but, although it converges right and left much nearer to the median line of the proximal side than in the last phase, it does not form a complete circle about the shaft. It is much the thickest on the distal side nearest to the nematocystic knob (α^2), and thins out gradually backwards, and passes insensibly into the ectophragma (f) of the aboral side of the umbella. Its true termination is indicated by the disappearance of the colletocysts, and by the edge (k^1) of the muscular layer. It thins out at the same rate at the sides (*fig.* 82), but rapidly loses in depth as it approaches the proximal side, and finally ceases to exhibit its characteristic features, the colletocysts, before it completely embraces the shaft. Its near approximation to the entire encirclement of the shaft is indicated by the great thickening of the opsophragma (n^2) along the median line of the proximal side.

170. All of the elements of a complete anchor are here well exemplified, both in point of distinctness and thickness. The opsophragma of the colletocystic portion (α^7) is nearly at its full grown *maximum* thickness on the distal side, near the knob, and equals in this respect the combined depth of the subjacent layers. Curiously enough, though, this proportion is reversed at the base of the organ, for as the opsophragma (n^2) decreases in thickness, the *gastrophragma* (i^4) increases in like degree, so as to be nearly as deep as the greatest measurement of the former. At no point, though, is the outer wall as thin as on the umbella proper; not even where it joins its homologue on the aboral side of the umbella, since there it does not suddenly cease its diminution in depth, but continues to do so for a short distance backward, until it attains a certain measure, and then spreads with a uniform thickness over the aboral area thereabout. The *myoplax* (m^3) is quite thick and sharply defined throughout the anchor, not excepting the tentacular portion. The *chondromyoplax* (b^2) is also equally well marked with the myoplax, and as thick, on the average, as the gastrophragma, but, unlike the latter, is nearly of uniform thickness throughout its length and breadth; only exhibiting a slight thinning at the sides of the anchor, and at the base of the nematocystic knob. The *gastrophragma* (i^1), except along the distal side of the anchor, is generally a little thinner than the chondromyoplax, but, like the latter, thins a little at the sides and at the base of the knob. In accordance with the preponderating weight of the colletocystic mass on the distal side, the internal cavity (α^4) of the latter projects in the same direction, much more than it does in any other, forming on that side a broad *diverticulum*. The average diameter of the cavity of the anchor in a proximo-distal direction is not more than one-third the measure at right angles to that. Within the base of the globose tip, however, it abruptly thins out to a narrow tube, but at its proximal end it gradually widens (*fig.* 82) into the general cavity of the umbella.

171. The *nematocystigerous*, globose tip (α^2) of the original tentacular shaft of this organ is quite densely crowded with the larger and smaller kinds of nematocysts. Up to this period, at least, there seems to have been an increased development of these cysts, both as regards their numbers and the perfection of their structure. In order that their present condition may be well understood, we refer to the figure (*fig.* 48) and description of the globose tip of a very young tentacle

belonging to the same individual as the anchor. After this time there seems to be a retrograde metamorphosis taking place in the nematocystigerous sphere, corresponding to the advancement of the colletocystigerous mass; but we are pretty well assured that this is rather an arrest of development, and a scattering of the cysts over a wider area, consequent upon the growth and expansion of the walls in which they are imbedded. The decrease in the number of the nematocysts does not necessarily imply a retrograde metamorphosis, for their disappearance may be accounted for in the habitual falling away of similar bodies in the tentacles, at all ages. Such a phenomenon in the tentacles assuredly does not indicate a retrograde metamorphosis; and the failure to reappear in the anchors means no more than an arrest of development. In the course of time, therefore, the characteristic feature which enables the observer to identify the tentacles with the anchors disappears in the latter, and a totally new one is implanted in its stead. This is but another proof added to the list which sustains us in the belief that the so-called retrograde metamorphosis is nothing more than *mimetism*, and a preponderating development of one or more parts of an organism, subservient to a particular end. (See ¶ 125.)

172. In the next phase (*figs.* 26, 27) of the anchor, which we shall illustrate, the colletocystigerous mass (αc^2) has united across the median line of the proximal face of the shaft (αc^7), and thus formed a complete circle about it. The animal bearing this organ measured a trifle more than one-fifth, say six twenty-fifths of an inch across the umbella (*fig.* 28). The specimen argues a certain amount of irregularity in the rate of growth and development of the anchors of this species, as one may judge for himself by comparing the figure of the phase now under consideration with that of the one preceding it, when he will observe that, notwithstanding the colletocystic mass of the older stage is more advanced than that of the younger, the terminal part of the shaft (*fig.* 83, αc^7) of the latter is the shorter of the two, and evidently has ceased to grow at an earlier period. The main progress which the oldest phase has made is exhibited by the very heavy preponderance of the colletocystic mass (*figs.* 26, 27) on the distal side of the anchor, extending obliquely outward and posteriorly, so as to almost equal the reach of the globose, nematocystigerous tip (αc^2). The latter, in consequence, arises from the oblique proximal face of the pad, and has rather the appearance of a lateral appendage than of a real terminus of the anchor. Still it preserves the tentacle-like physiognomy strongly enough to suggest its original form, and the colletocystic mass looks like a huge circular bolster set about its neck. The cavity (αc^1) of this organ, like the pad, preponderates so strongly on the distal side that at least four-fifths of it lies exterior to the longitudinal axis of the original shaft. Therefore, all of the tendencies of development toward a determinate end are here fully marked out, and nothing is wanted to complete the organ but changes in the proportions of the several parts.

173. These changes, however, are by no means small, although no new elements are introduced in the process. In the phase just described, the nematocystophore (αc^2) arises midway between the two extremes of the colletocystophore (αc^3) on its oblique proximal face, whereas in the full developed organ (*fig.* 47) the former

lies near the distal extremity of the latter, the first being indicated by a slight protuberance ($\propto^2$), dotted with a few nematocysts, and the last presenting itself under the guise of a huge, broad, oval mass ($\propto^3$), furrowed along one side, and simulating a coffee-bean in proportion and physiognomy. As an intermediate stage between these two last, we offer for inspection a figure of the anchor (*fig.* 25) of an individual which was two-thirds grown, or about three-fifths of an inch across the umbella. This view is designed principally to show the proportionate size of the nematocystophore ($\propto^2$), and its relation to the longitudinal furrow of the colletocystophore ($\propto^5$), and the latter is, therefore, foreshortened from its proximal face. The nematocystophore ($\propto^2$) still projects above the level of the main mass which surrounds it, the meagre remnant of a once vigorous organ. It will be seen, from these three views, that the change which transports the nematocystophore in the youngest stage to the extreme distal end of the colletocystophore in the fully grown animal, consists in the development of a very large proportion of the colletocystic mass on the proximal side of the clear space ($\propto^5$) from which the tentacular knob arises, and consequently throwing the latter into the extreme opposite direction. Accompanying this process there is also a gradual broadening of the mass until it becomes so much wider than the peduncular portion that the latter appears slender when contrasted with its former relative proportions in the penultimate and antepenultimate stages. We return now to the general description of the organs of the phase with which this section was opened.

174. *The Muscular System.*—The inconspicuous marginal muscle of the last phase has become in this a sharply defined, ribbed band (*fig.* 58, m^1), running along the same line as in the full grown animal. We have endeavored to display its internal face in our illustration by cutting open the circumoral parietes and throwing it back so as to expose its interior surface. From this point of view, the band may be seen thinning out, and finally disappearing as it reaches the base of the tentacular group. Concerning the rest of the muscular system we have nothing to say, except that the ridges of the opsomyoplax, in the umbella, are so well developed that the circumoral face presents as great a diversity of physiognomy, as far as these ridges affect it, as in the full grown animal, although not so strongly marked and conspicuous.

175. *Reproductive Organs* (*figs.* 67–73).—A clear understanding of the mode of development of the reproductive organs of *Lucernariæ* is of paramount importance, for more reasons than one. In the first place, they lie at the foundation of the *type idea* of this order, and, therefore, their exact relations to the walls of the umbella, and to its exterior and interior faces should be made manifest from all points of view. Their initiatory stages will, therefore, present them in their simplest form and connections, before they have become so complicated and extended as to obscure, more or less, the membranes from which they arise. This is, moreover, quite essential, because they can at that period be compared most readily with the reproductive organs in the other orders of Acalephæ. In the second place, we shall not find it so difficult to comprehend the situation of the inverted wall of the fully developed genital sac, with all its convolutions, if we trace it, step by step, from its simplest condition up to its most complicated form; and, again, the two cate-

gories of proof, as to its structure, insensibly merge into each other, and mutually sustain their position. It will become evident at the outset that the internal surface of the genital sacs was originally the free face of the general cavity of the umbella. In the description (¶ 135) of the full grown sacs we have pointed to the fact that the eggs are "sunken in pouches formed by folds of the lining wall;" that is, they do not lie beneath this wall, but against its free surface; the same surface that is continuous with the free face of the lining wall, *gastrophragma*, of the general cavity of the umbella. In all other orders of Acalephæ the eggs, or the spermatic mass, are actually covered by the gastrophragma; and some even by the gastromyoplax and chondromyoplax, and imbedded by the opsomyoplax. We have already noted the advent of the elements of the reproductive organs in the previous section, but special observations were not made until the present phase came to hand, and we possess, therefore, a wider range of development, in a single individual, than we could have obtained previously.

176. *The initiatory process* in the formation of a saccule consists in an abrupt rising of a thick, ridge-like fold, in the form of a semicircle (*figs.* 67, 68). The convex side (i^1) of the semicircle faces toward the periphery of the umbella, and the concave side (i) opens (at s^6) toward the proboscis. Thus in the very beginning one of the prime features, which render this order so singular, is established, as if it were an inevitable necessity to the completion of the type. The ridge is not an actual thickening of the oöphragma, but a clear duplication of this layer as it grows and rises above the general surface. The elevation increases but a little while, and then another phase of procedure is introduced (*figs.* 69, 70) which complicates matters to a slight degree. The concave side (i) ceases to grow as fast as the convex side (i^1), and the latter in consequence leans over towards the former, very much in the same manner that the crest of an incoming wave arches over its base just as it breaks on the shore. This goes on rapidly, especially midway between the two ends of the ridge, until a distinct hood is formed. This is the condition in which our figure represents the saccule, as seen from two points of view. The wall of the fold (i^1, i), it will be observed, is no thicker than its basal continuity (i). At this time the cavity of the new organ is quite deep from its broad aperture (s^6) to its innermost parietes (i), but it is very shallow.

177. Soon after this the aperture begins to narrow under the influence of the onward growth and contraction of the edge of the hood, and at the same time the cavity enlarges and becomes more nearly alike in breadth and depth. The first results is the formation of a narrow, rounded entrance (*figs.* 71, 72, s^6), on a level with the circumjacent area, and the second is accompanied by conduplicatures of the inner wall, at a considerable number of closely approximated points, resulting in the formation of little, shallow, wide-mouthed pouches or concavities (s^2) opening into the general chamber (s^1) of the genital. The latter is, at this period, about as broad in one direction as in the other, and not so deep, but rather preserves the proportions of a hemisphere attached by its equatorial face. Between the outer wall of the sac and the follicles there is scarcely any space except at the intervals about the latter. A short distance from the entrance, the wall is contracted on all sides, so closely as to fill up the passage way (s^6) to the interior com-

pletely, but immediately beyond, however, it expands laterally and diverges into the main fold. By plunging through the circumoral floor, and focussing up and down upon the saccules, we learn that the follicles do not develop at an equal rate throughout the cavity into which they open, but on the contrary originate progressively and grow at a corresponding rate. This is clear enough if we compare those which lie on a level with the aperture of the saccule with those which are placed at more distant points; the former appearing as scarcely more than shallow depressions (*fig.* 71) in the inverted wall, while the latter are to be recognized as unequivocal pouches (*fig.* 72, s^2) with a rounded contour and a narrow aperture. That all of the follicles do not originate at once is proved by a glance at the next figure (*fig.* 73) which we shall use to illustrate the series.

178. We now present the last phase of development of the saccules that we are in possession of; and we think that it is far enough advanced to connect the earlier stage of the organ with its full grown condition. There is really nothing new in point of character in the specimen (*fig.* 73), and it differs from the previous one merely in the greater size and more abundant follicles (s^3) opening into the general cavity of the saccule. Up to this period no trace of eggs nor of spermatic particles has been met with, neither, unfortunately, are we able to furnish any information in regard to the mode of origin of the reproductive material. The size of the saccule before us measures from one-fourth to one-third the diameter of full grown ones; and the follicles are as yet far less in number, amounting at most to only forty or fifty. The latter are a little larger than those of the last stage (*figs.* 71, 72), and press closely against the outer wall of the saccule.

179. *The Chondromyoplax.*—We return now to the more legitimate objects of this section, and take up in turn the successive layers of which the body is composed, as far as we have the material to work with. We find at this stage of growth the first tolerably clear differentiation of the *chondromyoplax* from the muscular layer. This is seen best in the oldest tentacles (*fig.* 59, *b*, m^2), and with rather more difficulty in the circumoral region. In either case it is not more than two-thirds as thick as the outer and inner walls in the same place, and from two to three times thicker than the muscular layer. In the anchors (*fig.* 32) it has a much greater depth, amounting to from three to four times that of the outer wall. As yet it appears to be perfectly homomorphous, a mere structureless, chondroid *stratum*. This is all we have to say, here, of the chondromyoplax. The description of its origin and mode of development belongs more properly to the histology of the layer.

180. *The Chondrophys.*—This layer is at least twice as deep in the umbella as the diameter of the oldest tentacles of the individual now in hand. Its histological elements are much more delicate than in the last phase, as far as it may be estimated from that part of it in the peduncle of the latter; and it is differentiated into two distinct *strata* (*fig.* 58, *c*, c^1). The outer stratum (c^1) is comparatively thin, not more than half the thickness of the outer, aboral wall immediately overlying it. Moreover, it, conjointly with the muscular layer, forms the partition which lies between the great mass of the chondrophys (*c*) and that part of the chondromyoplax which is in the tentacles. The inner *stratum* constitutes nine-

teen-twentieths of the whole chondrophys. The innermost of the three subdivisions of the chondrophys, so conspicuous in the full grown individual, is not to be seen as yet, although it is quite strongly marked in the next, and not much older phase (*figs.* 82, 83, c^4).

181. *The Nematocysts* constitute a marked and very conspicuous feature in the surface of the body, especially in the aboral face; forming numerous, thickly scattered, wart-like processes, by developing in closely set groups (*figs.* 30, 31, 32, *l*). On this account the outer wall appears much thicker than is really the case; although its true depth is considerably greater than on the tentacles. In the full grown animal these cnidigerous warts are so widely scattered that they scarcely attract attention. In *Calvadosia campanulata* they are, on the other hand, a singularly prominent part of the physiognomy.

182. *The Eye-spots* (*fig.* 32, θ).—In the paragraph (¶ 127, § 17) on the nervous system of the full grown animal we have enlarged considerably upon the relation of the so-called eye-spots to the visual function, and have spoken of them there as interstitial deposits of pigment matter. The present stage of development is the earliest one in which we have observed such accumulations. Here they form low bosses, extending over about one-quarter the breadth of the oral face of the base of the right anchors. The true nature of these bosses will be better illustrated in the next phase (§ 23), showing that there are certain concomitant features in the cellular mass of the wall in which they are situated.

§ 23. *Young,* $\frac{1}{5}$ *of an Inch Across.* (Pl. IV, *fig.* 48; Pl. V, *fig.* 53; Pl. VIII, *figs.* 81–84; Pl. IX, *figs.* 106, 107.)

183. By the time the umbella has reached the diameter mentioned at the head of this section the proportions of the body as a whole are very similar to those of a full grown individual, but are rather more slender. The transparency of the body renders it more light and airy in appearance than its elder companions, and in consequence seemingly less bulky and clumsy. The *tentacles,* however, still fall short of the proportions of the highest development; the shaft of the oldest members of a bunch being, as yet, relatively quite thick. The *anchors* (*figs.* 81, 82, 83), as has already been stated in a previous paragraph (¶ 169), have "lost a large part of the shaft of the tentacular form, and the globose tip stands out like a high knob on the oblique face of the colletocystigerous pad." Further details may be learned by reference to the paragraphs 169, 170, 171.

184. *The Muscular System.*—The *opsomyoplaxic* division of this system is clearly defined throughout the umbella (*figs.* 53, 83, m, m^4, m^6), and the tentacles (*fig.* 48, m^2), and anchors (*figs.* 82, 83, m^3), but the *oömyoplax* (*figs.* 53, 83, m, m^4, m^6), (¶ 74) is not visible. The former is distinctinctly fibrous, and of about equal thickness in the different members mentioned, although apparently less in the proboscis (*fig.* 53, m^6), on account of its more regular outline on its proximal face. In the latter organ, at this age, its abrupt termination at the mouth (ρ^1) is very distinctly seen without the help of the dissecting knife.

185. *The chondromyoplax* is more or less strongly marked by transverse stria-

tions in all regions of the body in which it is destined to develop. In the tentacles (*fig.* 48, b^1) it is on the average as thick as the outer or inner walls, and is very delicately striated. The same may be said in regard to the anchors (*figs.* 82, 83, b^1). In the umbella it is variable in thickness; in the circumoral area (*fig.* 53, b) it is fully twice as thick as either the outer or inner wall, but scarcely more than half the depth that obtains in the proboscis (b^3). Throughout, however, it is much more heavily striated than in the tentacles and anchors. In absolute thickness this layer has in the anchors from two to two and a half times more depth than in the tentacles and circumoral area.

186. *The Chondrophys* at the umbella exhibits a higher number of subdivisions than we have detected at subsequent periods. Of the three (*figs.* 82, 83, c, c^4, c^5) now visible, the innermost, thin substratum (c^1) was not observed in the last phase. This is the one which is conspicuous throughout the remainder of the existence of the animal, while the outermost, and by far the thinnest one (c^5), seems subsequently to lose its character as a separate subdivision. The latter in its earliest phase was very conspicuous, but in the present state it is quite faint, and nearly escaped our attention when the chondrophys was under the microscope. It is apparently quite homogeneous in substance, of a light yellow color, and about as thick as the outer, aboral wall. It is barely possible that it exists in mature individuals, but is so excessively faint as to require a special effort to find it. The main bulk, or middle portion (c) of the chondrophys, is enormously thick; equalling at least four times the diameter of the shaft of the oldest tentacles. Unlike the two thinner subdivisions, it is strongly striated in transverse section, and thickly penetrated by fibrous prolongations, which originate in the two outer subdivisions (see ¶ 197, A). Its marginal termination at the bases of the anchors has nothing of the abruptness of the mature form, but, rather, tapers off rapidly to a sharp edge where the muscular layer of the anchors intervenes (at k^1) between it and the chondromyoplax (b^2).

187. *The Opsophragma*, or circumoral (*fig.* 53, n) and proboscidal (n^3) outer wall, differs but little, if any, in thickness from that of the mature individual. Its proportion on the anchors (*figs.* 82, 83, n^2) has already been described (¶ 170), when the development of these organs was under consideration (§ 22). The *ectophragma* (*figs.* 82, 83, f), or outer wall of the aboral side, also closely approximates that of the full grown body in character and proportion.

188. *The Gastrophragma*, or innermost wall, at this age may be traced, with great facility, into its direct continuation with the opsophragma at the mouth (*fig.* 53, i^1) of the proboscis. It is there very thick, and continues so to the base of the proboscis, where it rapidly thins out and loses nearly two-thirds its depth as it passes along the circumoral area (i) to the periphery of the umbellar chambers. Its rapid thickening as it approaches and enters the anchors (*figs.* 82, 83, i^1) has already been touched upon (¶ 170) in the history of the development of the latter organs, and needs no further notice here, except to contrast it, at the present age, with its proportions and absolute thickness in the mature animal (*fig.* 47, i^1). It will be seen, by comparing the illustrations of the first (*fig.* 83, i^1) and of the last (*fig.* 47, i^1), that, in order to attain to the proportions of the latter, this wall must

diminish the relative thickness fully one-half, within the anchors, and to a far greater extent in the region of the passage-way (*fig.* 83, ψ^7) between the umbellar *cameræ*.

189. *The Eye-spot.*—At two or three points (¶ 127–130, 182) in the progress of this memoir we have enlarged more or less upon the functional nature of the so-called eye-spot. In addition to what has been already offered we would draw attention to the peculiar manner in which the pigment matter is disposed. We find it holding exactly the same relation to the prismatic cells (*fig.* 83, θ), *i. e.*, forming a dark casing or envelope about them, as the pigment does to the facets of the eyes of Articulata. Adding to this the evidently special character of these cells, as exhibited by their extreme elongation, and by their close aggregation and prominence at a given point, we have all that can be brought forward in favor of their functional characters as elements of an optical apparatus. Although we are not eager to assert that they are capable of forming distinct images of surrounding objects, we are, on the contrary, far from denying that they may possibly be capable of acting as refractive agents; since every cell that possesses a convex contour is a fraction of a lens; and a combination of such cells as we have here may constitute a whole lens in effect. It may not be unadvisable to state here that we hold, with others, that, notwithstanding the so-called eye of an insect is a compound of many *single* eyes, it none the less is *functionally* an optical *unit* so far as its effects upon the optic nerve is concerned; producing, like the pair of human eyes, but a single image on the brain.

§ 24. *Young, $\frac{6}{25}$ of an Inch Across.* (Pl. III, *figs.* 26, 27, 28.)

190. *The Anchors and Eye-spots.*—There is but one feature of this phase that our illustrations are intended for, and that is the condition of the *colletocystophores* or anchors. The prehensile portion (∞^3) of these bodies has been described in a previous section (§ 22) with considerable fulness, and therefore needs no further notice here, but the so-called *eye-spot* (θ) remains yet to be considered, although it has also been touched upon in preceding paragraphs (¶ 127, 189). We have nothing in the way of details to add to what was given in regard to the preceding phase (¶ 189), but we may say a word or two more in reference to the latest condition in which this organ has been observed. It now attracts the attention of the observer by its distinctly marked outline, deep color, and particularly by its boss-like prominence (*fig.* 26, θ). It is remarkable for appearing to be possessed of a lens imbedded in its middle; but this is a fallacy arising from the more abundant accumulation of pigment granules in the periphery of the eye-spot than at the centre, and hence a comparatively clear area is left in its midst. After this period the eye-spot is gradually lost sight of; but still we cannot say positively that its functional character is obliterated, for we are not sure that it is possessed of such at any time; and it may possibly retain all its potential features, even when, in extreme old age, it is obscured, to the eye of the observer, by the abundance of diffused pigment spots all around it.

CHAPTER VII.

HISTOLOGY OF HALICLYSTUS AURICULA.

§ 25. *The Umbellar and Peduncular Walls.*

191. In some respects it would be better to connect the histology of the parts and organs of the body with their general structure, so that all their characteristics might be presented in one view; but there are other and weightier reasons why a separate chapter should be devoted to the intimate structure of the tissues. In the first place the subject and arrangement of the sections are rendered much less complicated and clearer for comparison; and again, it leaves more room for the discussion of collateral questions, such as the *cell-theory*, and the like, without involving the confusion of parenthetical sentences and explanatory notes. Yet we shall so arrange the sections that each may be read as a continuation of any previous one devoted to the general description of a corresponding organ or part. In accordance with this purpose we begin with the outermost wall of the anterior face of the umbella.

192. To those who accept the theory that the tissues of Acalephæ, and other groups of this grand division, are composed of true cells, wherever there is the *appearance* of such bodies, it will come with most force, when we state that in *Lucernariæ*, as in other orders of the class, there is but a *single stratum of cells* in each wall. If we except the family *Tubularidæ*, this may be announced as a *law* among all *Acalephæ*, both in the hydroid as well as in the medusoid morph. In most highly developed medusoid morphs these strata are so excessively thin, that is to say, the component cells are so shallow, that they have more of the character of a filmy epithelium than of a true wall; whereas in the hydroid morphs it frequently happens that some one of the layers is so thick as to constitute three-quarters or more of the whole bulk of the body. In Lucernariæ we find these two extremes indiscriminately intermixed.

193. *The opsophragma* (see ¶ 61, 62) of the umbella (*figs.* 74, 85, 86, n–n^3) is composed mainly of the single stratum of cells which are so conspicuous, even to a casual observer; but these cells are by no means all that give bulk to this layer, for they stand at more or less considerable distances apart from each other, and the large interspaces that intervene add greatly to the physiognomy. In fact the color of this region is almost altogether due to the large masses of pigment granules (e^2) which crowd these interspaces, and underlie the cells; and the latter are rendered all the more conspicuous by the dark ground-work in which they are imbedded. The *cells* are not arranged collaterally in any particular order, nor have they a uniform size, some being at least twice, and occasionally three times the diameter of others; on the average they are about one-quarter deeper than

broad. Their true, exterior boundary is irregularly polygonal, but rather inconspicuous on account of the abundance of the pigment masses thereabout; whereas the interior boundary, which is an irregular oval, or sometimes obscurely polygonal, is very sharply and distinctly marked, and moreover so conspicuous as to give the stratum, under a low magnifying power, the appearance of being a mass of dark, granular blastema, filled with clear vacuoles. It will be seen from this that the exterior and interior faces of the cell-membrane (*d*) are not parallel, in other words, that this membrane is of unequal thickness; and, from the nature of things, incrassated most at the angles. On the whole it is quite thick, but yet plastic to a considerable degree, both in reference to lateral pressure and to whatever tends to increase its depth at the expense of its breadth. The extensibility of this layer, however, is not altogether a property of the cells, for the interstitial substance is not to be overlooked, nor have we any reason to believe that it is less plastic or dilatable than the vesicles. Nor, on the other hand, do we admit that either the one or the other is capable of extending or retracting itself, unless we altogether ignore the muscular layer (*opsomyoplax*, *fig.* 85, *m*), which presses closely against the inner face of this wall. The contents of a cell are of two kinds, and very simple in quality so far as their mechanical, or rather physical, nature is concerned; the one is a perfectly homogeneous, fluid-like, colorless, slightly refracting mass (d^2), filling the entire inclosed space, with the exception of that occupied by the nucleus, which is the other part of the contents. The *nucleus* (d^1) is the most noteworthy feature of the cell on account of its invariable lateral position. Without an exception we have always found it attached to the cell-membrane between the exterior and inner ends of the cell, *i. e.*, against the faces of mutual contact. Here we should naturally expect to find it, in a wall composed of a single *stratum* of cells, which grows by self-division of its components, the nucleus, as is well understood, lying in the line of separation. This uniformity of position is carried still further, for the nucleus seems to be fixed about midway between the two extremes of the cell, so that in a profile view (*fig.* 85) of the stratum they appear as if arranged in a row when observed collectively. We shall see presently that this arrangement is still more striking in the corresponding wall of the tentacles. The outline of the nucleus is tolerably well defined, but not sharp nor rigid, and the whole presents a uniform, quite conspicuous, colorless, semi-transparent, lenticular mass, attached by one of its broad sides to the cell-membrane. On an average its diameter is about one-fifth or one-sixth the depth of a cell. The *intercellular blastema* not only lies between the cells and beneath them, but completely covers their outer, free ends, and therefore it may be said, without exaggeration, that the cells are completely imbedded in the blastema. The pigment (e^2), which gives color to this formless mass, consists of irregular granules of great diversity in size, some equalling the nuclei of the cells, and others measuring less, and so on down to those which are, comparatively, mere specks. The larger granules usually alternate with the cells, filling the interspaces at the angles with a highly refracting, often brilliantly colored mass. The finer and speck-like granules crowd the blastema which overlies the ends of the cells, and lend considerable aid in imparting color to the wall, in fact giving uniformity to the tint, which otherwise would run like a network in the interspaces. Frequently highly refracting, large, oval, or globular bodies (*l*) may be observed, mixed with the coarser pigment, at the junction of three or four cells. A close examination proves these to be urticating vesicles (*nematocysts*). Their refracting power renders them quite brilliant objects, and lights up the face of the wall with bright, salient points. The bristle-like projections, which are often observed on the free surface of the wall, are portions of the blastema which are apparently thrust outward by the partially extruded filaments of the nematocysts. More will be said of this hereafter, in the description of these offensive weapons (§ 30), and the true relation of the bristle-like bodies will be amply explained. (See also ¶ 203 (A)).

194. *The ectophragma* (¶ 63) of the umbella and peduncle (*fig.* 87) consists of cellular elements which exhibit a close affinity with those of the *opsophragma* (¶ 193), still there is a decided and readily observable difference between the two. The cell-membrane, the exterior and interior configuration of the cells, their size and proportion, their mode of arrangement, the fluid-like contents, and, finally, the granular interstitial blastema, might all be described in the same words as used for the components of the opsophragma. The main diversity then is narrowed down to the character of the *nucleus* (d^1), and this we shall find is not inconsiderable. Strictly speaking, the nucleus is no longer visible, if it exists at all, and seems to be either covered up, or replaced by very dark, highly refracting, irregular, large granules, which are heaped together in twos, threes, or fours and fives at the side of the cell. Occasionally they are detached and lie in the midst of the homogeneous contents. These *pseudo-nuclei* are many times larger than the nuclei of the cells of the opsophragma, and such is their opacity and intensity of color, to say nothing of size, that they effect far more, in producing the tint of this stratum, than the interstitial, granular blastema (*e*). Hence it is that this face of the umbella is darker than on its front. We should add, also, that the nematocysts (*l*) are more numerous than at any other part of the exterior of the umbella, and frequently are collected in groups of from three or four to a dozen, glittering, from their strong refraction, like clusters of jewels.

195. *The opsomyoplax* (¶ 64) of the umbella (*fig.* 85, *m*). In the general description of this layer we have stated that it uniformly spreads beneath the opsophragma, and that it is made up of fibrillæ which are placed side by side. We premise this much here in order that we may also recall the arrangement of similar fibrillæ in the tentacles, in which they are disposed, in a broken stratum, at regular distances apart, in groups or bundles. These are the main differences of the muscular system in the two regions in question, and therefore the description of the histological elements of the one may serve for that of the other. Inasmuch, however, as we have illustrated the microscopic structure of this layer in the tentacles with such fulness of detail, and under more advantageous circumstances than could be had elsewhere, we shall refer the reader to the description of the histology of those organs for whatever information may be desirable in regard to the composition of the fibrillæ. The cellulo-fibrous elements are alike in both. We refer also to paragraph 199 for a description of the still more highly developed muscles of the peduncle.

196. *The Chondromyoplax* (¶ 65–68) of the umbella. We have, on more than one occasion, in various papers, urged the necessity of the closest and minutest, critical observation of the details of all parts of the body of an animal; leaving no point untouched as if it were of too slight importance to deserve more than a passing notice, or as if it had no direct relation with the rest of the organization. The piecemeal manner in which the anatomy of living beings is frequently worked out, a few notes made here, and a few there, with no particular reference to anything except to the novelty of the subject in the mind of the observer, has no doubt led on to the meagre, scattered, and unsatisfactory results which lie hidden in innumerable periodicals, journals, memoirs, and even the popular papers, weeklies and dailies. One cannot sometimes help fancying that a large part of the so-called *facts* of science are the result of the labors, or we might say the struggles, of innumerable incompetents, who, like some of the inmates of an insane asylum, delight in secreting valuables in out of the way places. The lower we descend among the inferior ranks of animals the more directly do the histological elements appear to be connected with the plan of their organization. No doubt this is owing in a large measure to the want of diversity in the form of the organs and their slight degree of differentiation for physiological or other purposes. In fact we might venture to say that a differentiation of histological elements precedes that of organs and regions. That this is most notably so, in some cases at least, no one who is familiar with the muscular system of Ctenophoræ, and especially with that of Pleurobrachia or Cydippe, need doubt. In these creatures the bulk of the body is made up of a gelatiniform mass, which at first sight appears to be homogeneous throughout. Closer scrutiny reveals the fact that it is not so, but composed of two elements; *the one* a clear, transparent, homogeneous, all-pervading, jelly-like substance, and *the other* dispersed throughout the latter in the form of innumerable, hyaline fibres. These fibres, however, are not scattered irregularly here and there, but disposed in a most orderly and methodical manner; yet still do not attain to the main essentiality of true differentiation, viz., segregation and concentration into a well defined organ; but, on the contrary, the fibres of one group thoroughly intermix with those of another, and cross and recross each other without confusion. Thus, then, we see that a differentiation into contractile and non-contractile tissue is decided, whilst a differentiation into distinct organs is but half carried out—merely foreshadowed. The plan of the arrangement of the *fibres* is inseparable from the plan of the arrangement of the *groups* which they compose, and the first plan precedes the second. Such and similar considerations have led us to give more than a passing glance at the disposition of the histological elements of the gelatine-like mass of the body of Lucernariæ. Not only do we find in Haliclystus a muscular system developed to the highest degree among Acalephæ, but also the elements of the *chondrophys* and *chondromyoplax* arranged with a greater preciseness and method than can be observed in any other order. It is not a little remarkable, too, and as if confirmatory of the high rank which we claim for *Lucernariæ*, that the arrangement of the fibrillæ in the *chondrophys* of the peduncle recalls the disposition of those in the *Ctenophoræ*, in spite of their clearly diverse function. Looking at the *chondromyoplax* from a physiological point of

view we have hesitated slightly as to whether this stratum is altogether separate from the *opsomyoplax* and the *oömyoplax*. The forms of the histological elements are different enough, as we shall show presently, and have homological relations distinct from each other; but we believe that the *chondromyoplax* must be looked upon in the light of an *elastic connective tissue* of the muscular layer, and intermediate between it and the adjoining layers, the *opsophragma* on one side and the *gastrophragma* on the other. The fibrillæ of the tissue (*figs.* 53, 74, 77, *b*, *b'*) are highly elastic; but in no other respect do they exhibit any affinity with the muscular fibrillæ. They are purely homogeneous throughout, with not a trace of anything like a nucleus; in fact, they have more of the appearance of aciniform streaks in a homogeneous, jelly-like mass than aught else we can compare them with. They seem to be direct prolongations of the fibrillæ of the muscular layer (*m*), but that they are not such is proved by their well-marked histological differences. There can be no doubt that the muscular fibrillæ confine themselves strictly within the horizon of the *opsomyoplax*, as we have illustrated most fully in the tentacles, and that the fibrillæ of the *chondromyoplax* alone stretch at right angles to the surface of the layer, directly across its thickness. Consequently, in a section of the depth of this layer, it appears to be transversely striated. The fibres do not, however, always trend through the layer very strictly at right angles, but more or less obliquely to the surface; nor are they of equal breadth throughout, but taper gradually from a base of considerable width to an infinitesimal point, often extending two-thirds or three-fourths through the layer. As they are based on the opposite faces of this layer, their tapering points meet and cross each other at the middle of the thickness of the stratum intervening, as it were, just as the bristles of two brushes do when forced together face to face.[1]

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[1] (A) The question here very naturally arises as to what is the mode of origin of these fibrillæ. In most connective tissue, as is well known, we may find nuclear bodies scattered here and there among the fibrillæ, but in that which we have now in hand there is nothing of the kind. Have we not here then an independent fibrillization of a cytoblastema? If Virchow and Beale and their numerous adherents admit that a cell need not have a cell-membrane, and requires only the presence of some one concentrated material as the centre of centripeto-centrifugal changes and developments in order to be a *cell*, or "*elementary part*," what must we call these self-originating fibrillæ of the chondromyoplax? The same question applies with equal, if not greater, force to the muscular fibrillæ of Ctenophoræ, and our inferences are the same. We cannot see that they lie within the boundaries of a "*cell-territory*" of Virchow; nor at any time or age have we detected "germinal matter" of Beale among them. Why should they not be classed as the original "*elementary parts*"? They seem to have originated spontaneously, and we feel compelled, therefore, to admit that they have all the value of cells in the most modern acceptance of the term. We are the more easily led to adopt this view after having convinced ourselves that *cells* so-called (no matter whether constituted according to the older histologists, or according to the most recent theory) are, after all, of secondary importance, and that the *cytoblastema* (which we do not distinguish from intercellular substance) is the main and *essential element*, the potential progenitor of all tissues, and that it projects itself into the utmost future of the living body by a process of self-proliferation. Through this, and this only, can a true *law of continuous development* be illustrated; whilst the various forms of cell tissue, and fibre-tissue, and bone-tissue, etc. etc., are but the disjointed, collateral developments, each one irrespective of the other, from the continuous, onward stream of cytoblastema. Among the Protozoa, particularly the Amœboids and their Rhizopodic congeners, the cytoblastemic condition of the *ovum* is continued unchanged, as to form, in the adult stage; and so, as we have said in a previous para-

197. *The Chondrophys* (¶ 69) *of the umbella* (*figs.* 82, 83, *c*, c^2, c^4, c^5, 106, 107, 109). In the same way that the chondromyoplax stands as an elastic connective

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graph (¶ 129), all Rhizopods are "moving, sentient masses of *Cytoblastema*," and that alone. Here, then, one cannot doubt that cytoblastema is self-proliferous when an Amœba grows. It is most generally adopted as a theory that the cells, of which a wall or tissue is composed, are of *primary* importance, not only in the adult age, but *ab initio;* that it is to the cells that the wall or tissue owes its existence *primarily*. This seems to be the opinion of most histologists, from Schwam down to Virchow and Beale. Schwam (Mikroskop. Untersuch., 1838) claims that cells crystallize out, as it were, from an amorphous cytoblastema. The *nucleolus*, when present, originating first, and condensing around it material for *nucleus*, and the latter carrying on the operation begun by the nucleolus; that they have a *metabolic* power of drawing from the cytoblastema material for development and producing chemical changes in it, while the cytoblastema itself remains *passive*, merely furnishing the nutriment for these purposes. In order to account for the *initial impetus* he is obliged to assume that the cytoblastema is heterogeneous, that it is studded with numerous points of greater density than the general mass, and that at these points a tendency is exerted which draws surrounding material toward them, very much in the same way, he argues,—although he does not positively insist on an identity,—that crystals are induced to form around or in certain areas of condensation. This amounts, after all, and however much he may wish to make it appear otherwise, to an admission that the cytoblastema has within itself the *originating* power of cell-formation. And, moreover, this admission is enhanced by his asserting that the cytoblastema is self-generating, *i. e.*, *proliferous*, and that often the nucleus is an undefined mass for a long time after the peripheric portions of the cell have begun to develop; thus divulging the fact, although unwittingly, that the area of condensation is not precisely about, and in reference to the power of one body, but that this body, or *nucleus*, is merely the guide-post which assists the congregating particles of matter in arranging themselves in symmetrical order in reference to some one lateral point in the cell. Schwam interprets it differently, however, and claims to have proved that the nucleolus, nucleus, and cell-membrane each attracts to itself, and by its own inherent power, material which differs from that entering into the composition of the others. We must quote him, therefore, for what he claims, and not for what he proves, strictly speaking. All animal tissues, in the opinion of this author, are originally cellular, but a part of them cease to be so by a transformation of the cells into tubes, or fibres and fibrillæ. He does not, though, go so far as his successors, and claim that a cell necessarily has a membrane about it; on the contrary, he says that "many cells, however, do not exhibit any appearance of the formation of a cell-membrane, but they seem to be solid, and all that can be remarked is that the external portion of the layer is somewhat more compact." In this respect he anticipates the theory of Beale, and also of Virchow, of late.

(B) Virchow originally, like others, demanded that a body must have a distinct wall about it in order to be a cell, and denied that cells developed by free cell formation, *i. e.*, without the intervention of previously existing cells; his motto was *omnis cellula e cellula.* He agreed with Schwam that cells have a self-asserting power, and went beyond him in attempting to prove that they exercise a control over the interstitial substance, insisting that "the intercellular substance is dependent in a certain definite manner upon the cells, and that it is necessary to draw boundaries in it also, so that certain districts belong to one cell, and certain others to another." (See Virchow, "Cellular Pathology," translated by Chance) But he also takes considerable pains to impress upon his hearers that interstitial substance is *not* cytoblastema, and that the latter formative fluid does not exist in nature; thus taking away the very foundation of free cell formation. If, however, we are to believe information which comes to us at second hand (see "Edinburgh Med. Journ.," February, 1865) Virchow "now did not regard a cell wall as an essential part of the cell, as given in cellular pathology, but that a nucleus surrounded by a molecular blastema was sufficient to constitute a cell." This certainly looks like going back to Schwam again, and, as he makes the presence or absence of a cell-membrane of no account, the *cell* is left in more open communication with the interstitial substance; the "*cell territory*" is scarcely to be distinguished from the *cell* proper, whose influence radiates into its furthermost boundaries. While Schwam asserts that the interstitial substance (*cytoblastema*, tissue in the oral face of the umbella, so the chondrophys is to the walls and organs of the aboral region. But we are inclined to class the latter with inelastic, fibrous connective tissue, like Kölliker's *reticulative connective tissue*, or something between that and *fibro-cartilage*. If the fibre-like bodies (c) in the chondrophys are, as we hope to demonstrate, of the nature of cells or "elementary parts," we think we should be not far from correct if we set this stratum down in the category of *cartilage*, the fibre-cells taking the place of cartilage-cells, so called. In the earliest stages of growth the true, cellular walls, the gastrophragma (i) and the ectophragma (f), of the aboral side of the umbella and of the pedicel, lie closely apposed to each other; but in course of time they begin to separate and the intervening space is at the same time filled by an amorphous hyaline substance in which are imbedded irregular bands (*fig.* 129, c^2) of less transparent matter, sparsely dotted by granules. These bands at first are continued from wall to wall, but as development proceeds they become clearer, less granular, more elongate and straightened, and thinned out at the middle, so that they resemble a very slender hour-glass (*figs.* 82, 83, c). In the last condition they have, in a general way, the appearance of structureless fibrillæ traversing the thickness of the amorphous hyaline substance. The latter and the former constitute the *chondrophys*. In their earliest or granular condition they evidently are amorphous bodies, differentiated out of the "hyaline substance;" and, notwithstanding their form, may well be identified with the nucleus of an "elementary particle." Their subsequent development has all the appearance of the strongest proof of the truth of this view, for they are finally invested by a distinct membrane (*figs.* 106, 107), which can be nothing else than the homologue of a cell-membrane. These fibrillæ then are extremely elongate cells in a low state of development, in which the periphery has become differentiated into a distinct *wall*, while the contents (d^2) have remained

Schwam) remains passive and unchanged, except in growth by direct *proliferation*, and that the nucleus draws from it nutriment which it changes chemically into cell-material; Virchow attributes to the nucleus, or rather to the cell, the faculty of producing changes in the intercellular substance itself; each cell having a well-defined "*cell-territory*" over which it presides, at one time causing a fibrillation of the blastema (*fibrous tissue*), or an increase in bulk of the same without any perceptible change, as at the ends of the bones where *cartilage* prevails, or another form, among the membranous supports of the body, *connective tissue*. Beale (various works, and particularly "How to Work with the Microscope" 4th ed., 1868) admits the existence of a cytoblastema (his "nutrient inanimate matter," lifeless pabulum), yet does not identify it, like Schwam, with intercellular substance, but says that "*oval bodies*" (nuclei, or more or less developed *cells*) originate spontaneously, *i. e.*, by *free cell development*, and then by a process of absorption and exfoliation convert the surrounding blastema into various forms of interstitial substance, such as the ordinary intercellular material, or cartilage, or fibrous tendon, etc. etc.

(C) Putting it more concisely, now, we may say that while Virchow asserts that cells never spontaneously originate themselves, but continue their kind by *proliferation*, by "an external law of *continuous development*," and also cause the interstitial substance to *grow*, and to change into fibrillæ, etc. etc., as a mere outskirting appendage of the cells, inseparable from them, Schwam, on the other hand, attributes to cells the power of self-originators by *free cell development* out of a cytoblastema, and that it is the latter, the *cytoblastema*, which is independent, self-generative, *i. e.*, *proliferous, ab initio ad finem;* and finally, Beale differs mainly from Virchow, and agrees with Schwam, by insisting upon free-cell-development, but not in a genuine cytoblastema.

undifferentiated from the nucleus. Their distal ends lie in close contact and thereby have become polygonal, and present the appearance of an irregular network when this stratum is seen from either of its faces (*fig.* 106). We must not omit to mention, also, that the cell-membrane is ribbed lengthwise (*fig.* 107) with the cell.

197 (A). Another peculiarity in the disposition of these cell-fibrillæ explains the apparent subdivision of the chondrophys into three layers (*figs.* 82, 83, *c*, c^1, c^5). Where their ends are crowded together their membranes become partially fused into each other, and seem to lose their refractive power, and become more transparent; so that their outlines are exceedingly faint. Now if we observe carefully, we may see that they are applied against each other to a certain length, forming thus a sort of pavement-work, of a definite depth, and then they all together, along one horizon, abruptly separate from each other and taper off toward their mid-length. The pavement-work, then, at each end of the fibrillæ, corresponds to the two pale subdivisions (c^1, c^3) of the chondrophys (see ¶ 186), next the gastrophragma and the ectophragma, and the middle subdivision, to the region in which the fibrillæ are tapered down to a slender waist. The finer and parallel striation in the two pale subdivisions is due to the longitudinal ribs of the fibre-cells. The outermost subdivision is at most not more than one-third as thick as the inner one, and becomes obliterated in the advanced stages of growth, by the retraction of the parietes of the fibre-cells until they cease to touch each other, except at their extreme termini, where they abut against the cells of the ectophragma. That these fibre-cells are not fibre-like hollows, or plications of the amorphous hyaline substances, is proved by an inspection of a cut surface of the chondrophys, made by a section through its thickness, when the fibrillæ will be found more or less curled or bent, and projecting loosely (*fig.* 83, c^2) from the matrix in which they were developed.

197 (B). The size of the fibre-cells varies considerably, but within certain limits. They are never so small as to cover less than three or four of the cells of the walls upon which they rest, and sometimes they extend over half a dozen of them. In this case, then, they cannot have been developed within any of Virchow's "cell-territories," to say nothing of other reasons, given above, why they could not have originated thus. As a general thing they extend directly through the thickness of the chondrophys from the gastrophragma to the ectophragma; but there are some modifications of this at certain points. We have shown in a previous section (¶ 67) that, at the partitions of the umbella, the chondromyoplax and the chondrophys lie in immediate contact; the gastrophragma failing here. Consequently the proximal ends of the fibre-cells of the chondrophys (*fig.* 83, c^4) abut against the inner ends of the fibrillæ (fibre-cells!) of the chondromyoplax (b^8). At the edge of the umbella, along the intertentacular margin and at the base of the tentacles, the *distal* ends of these fibres abut against the muscular partition (*figs.* 60, 61, 62, k^1), which separates the border of the chondromyoplax from that of the chondrophys. At the anchors (colletocystophores) it appears that the *proximal* ends of these fibres abut against the muscular partition (*fig.* 83, k^1). If now there were any derivative connection between these fibres and the adjacent walls, they

ought, it would seem, in order to be consistent, to diverge in the partitions of the umbella toward the proximate points in the gastrophragma, instead of trending directly to the chondromyoplax (*fig.* 61, *b*). In the peduncle (¶ 198) we shall see that they exhibit still less relationship with the gastrophragma.

198. *The Chondrophys of the Peduncle* (¶ 71).—The fibre-cells (*fig.* 52, c^1, c^4) of this layer in the peduncle have the same form, properties, and no doubt the same origin as those in the umbella, but they are so singularly arranged as to make them worthy of special consideration. Those lying next the periphery trend in direct parallel lines from the ectophragma (f^1) to the lining wall (gastrophragma) of the four cameræ (τ^3), except where they are interrupted in their course by the four muscular cords, and in that case their proximal ends abut against the latter (*r*). Beside the peripheral set there are no less than seven others; and these do not reach to the ectophragma, but are restricted to an area within the circle of the four cameræ and the four muscular cords. Five of these sets lie between every two adjoining cameræ, crossing each other at either very acute or very obtuse angles. The sixth and seventh cross each other at right angles through the axis of the peduncle. In all cases they curve outwardly to a greater or less extent toward the axis. For the sake of convenience we will give each set a number, supposing the observer to be on the outside of the peduncle, and one of the muscular bands (*r*) nearest him. In what we may call set number *one* the fibres extend from the proximal face of the three-sided muscle to the camera on the *right*, diverging in such a way that those arising on the extreme right of the muscle seek the nearest point of the camera, striking at about half way between its distal and proximal sides, while those arising on the extreme left of the muscle run to the proximal side of the camera, and those starting from intermediate points on the muscle strike intermediate points on the camera. Set number *two* start from the same face of the muscle as number one, but trend to the left, and abut against corresponding points in the camera on that side. Consequently the fibres of sets numbers one and two cross each other at right angles. The fibres of set number *three* arise from a limited area half way between the proximal and distal side of the camera on the right end, converging slightly, trend to the left and strike the camera on that side at its proximal border. Set number *four* are arranged exactly as in number three, but originate on the left and terminate on the right, the fibres of the two crossing each other and also those of set number one and two at an obtuse angle. The fibres of set number *five* pass in the most direct way between two adjoining cameræ, arising at all intermediate points between the proximal side of the cameræ and a point half way to the distal side. They therefore cross the sets, number one, two, three, and four, at a variety of angles, which gives them, when taken together, a very complicated appearance. So far the sets between any two adjoining cameræ are unmixed with those of any other two; but we come now to two sets, number six and seven, which partially bind them to each other. Set number *six*, instead of joining two neighboring cameræ, connect two which are diagonally opposite; for instance, the nearest on the right and the most distant on the left. The fibres then cross the axis of the peduncle, and abut against the proximal side of the cameræ, and for a short distance toward the distal side. In doing this they cross,

at various angles, a part of those of sets numbers one to five. Set number *seven* has the same relation to the other two cameræ as that which number six has to the first two mentioned, and crosses the latter at right angles in and about the axis. These two latter sets are the only ones which occupy the axis, the others forming an intricate inclosure about it, the fibres of number four approaching nearest to the centre, and forming a quadrangle between the proximate sides of the four cameræ. In point of complexity and regularity of arrangement, combined, there is nothing in the whole class of Acalephæ that can approach what we have here described, and it is to be matched only in a higher class, the Ctenophoræ. In the youngest specimen, about one-eighth of an inch across the umbella, the fibres of these sets (*fig.* 128, *c*) are much less numerous than in the full grown animal; in fact those of numbers three and four are not made out. It is remarkable, too, that fibres of numbers one and two penetrate the hollow of the cylindrical muscles. At the extreme posterior end of the peduncle (*fig.* 127, c^1), where the chondrophys forms a part of the floor of the transverse "adherent disk," the fibres pursue a different course, gradually verging around from their position in front until they assume a trend which is at right angles to that, and consequently parallelwise with the longitudinal axis. In this region their arrangement seems to be reduced to the utmost simplicity, all trending uniformly in the same direction.

198 (A). As to the mode of origin of these fibre-cells very little can be added to what has been said of those in the umbella proper, except to confirm the view there expressed by referring to their multiple decussation in the peduncle. It is plain that the cells of the gastrophragma have nothing in their arrangement upon which so many varied positions of the fibres could be based, all at the same time, and there are certainly no other cellular collections near at hand, but in the muscular cords. The all-pervading, hyaline substance, then, is our only resort, from which to derive the fibres that are imbedded in it. Just as the crystal lays down its faces and angles in definite relation to its several axes, so may the less inanimate, more highly endowed hyaline substance of the chondrophys apportion to each fibre-cell its place and attitude in reference to its fellows, and that, too, without going beyond its own boundaries, or self-evident area of activity.

199. *Histology of the Peduncular Muscles* (¶ 59, 88) (*fig.* 116).—The fibrous appearance, which these muscles present under a moderate magnifying power, is deceptive, and is due to the longitudinal folds and not to the visibility of the fibrillæ. The latter, on the contrary, are so excessively transparent and fine as to require a high power and a very clear definition to even so much as detect them. In addition to this there are very serious obstacles in the way of isolating the fibrillæ (*fig.* 116, r^3); and these are nothing less than numberless globules or spheroidal cells (d^1), which pervade and crowd the tissue. Indeed these cells, varying considerably in size, constitute one-half, at least, of the bulk of the muscle; and by reason of their conspicuity seem to form a purely cellular tissue (*fig.* 114) with large intercellular spaces. More careful research revealed the fact that these apparent interspaces are occupied by a close network of anastomosing fibrillæ (*fig.* 116, r^3). The latter, no doubt, are the true motor agents of the muscle, while the globose cells form the framework for support and attachment.

The fibrillæ vary somewhat in their proportions; some being very slender and thread-like, and others more or less fusiform and irregularly nucleated, or granulated. They all run out into exceedingly thin infinitesimal points, or at least two opposite sides, and some have three or even four such prolongations (1 r^3). Their anastomoses do not seem to be formed by actual organic fusion, so as to obliterate their lines of contact, but are mere approximations resulting in a mechanical adhesion of contiguous surfaces. The general trend of the fibrillæ is parallelwise with the axis of the muscle, but it is slightly modified by the lateral anastomoses.

199 (A). That the spheroidal cells are intimately connected with the fibrillæ would seem to be incontestable after an inspection of our illustration; and even more than that, for so closely wrapped are they, frequently (2 r^3) by the anastomosis of neighboring fibril-cells, that they have almost led us into the belief that they are the nucleolated, gigantic nuclei of the latter. The common occurrence of fibril-cells without such encumbrances (r^3), and the high improbability of the existence of nuclei of such large proportions and complicated structure, prevented us from entertaining the idea after serious consideration. We may add, also, that in other parts, *e. g.*, in the tentacles, where the fibrillæ have been made subjects of a special investigation, there is not a trace of such cells (¶ 204). Not only are the spheroidal cells themselves very conspicuous, but also the single nucleus (d^1) of each. The latter is, moreover, very large, and frequently fills more than one-third of the diameter of the cell. Its outline is as distinct as that of the latter, and less transparency renders it a rather more prominent object.

200. *The gastrophragma* of the umbella and peduncle (¶ 75). In the digestive chamber proper the cells of this layer differ very little in character from those of the ectophragma, and that is not so much in themselves as in the intercellular blastema, which is nearly barren of pigment granules. There is, however, a much wider range in size and proportion among those of the gastrophragma, though they remain, as everywhere else, in a single *stratum*. Only the greater part of the interior the cells (*figs.* 74, 77, *i*) are like those of the ectophragma in breadth and depth, but at certain points they depart greatly from this, viz., at the entrance to the cavity of the anchors they rapidly thin down to mere scales, like epithelium (*fig.* 94, C), and their large, dark, irregular nucleus (*fig.* 95, d^1) dwindles in size and intensity of color. In the *peduncle* (*fig.* 105) we find the reverse, usually, and especially where irregular passage-ways are being formed by the resorption of the chondrophys (c^1) between the four cameræ, and the development of the gastrophragma (B, C) as a lining. Here the cells have a depth more than double their breadth, and the nucleus (*fig.* 105, d^1) appears again very large from a great accumulation of pigment matter about it. We find here, also, as in the ectophragma and opsophragma, that the nucleus adheres to the side of the cell, but near its attached rather than its free end. The cells, moreover, have an exceeding brilliancy, an illumined look; no doubt owing, in part, to their freedom from intercellular pigment, and in a measure to the strong contrast produced by the intense, dark, highly refracting nucleus, in the homogeneous contents, of a singular vitreous transparency. On the genitalia they are, sometimes at least, several times deeper than broad (*fig.* 109, d^2), and the nucleus (d^1) is small and transparent. They

assume this proportion, also, frequently near the partitions, in the region of greater muscular activity (*fig.* 104, *i*).

201. *Vibratile Cilia* (¶ 77).—In describing these bodies here the principal interest to the histologist concerns their mode of relation to the cells upon which they seem to be based. It is commonly received as a dogma that vibratile cilia are direct prolongations of cells, forming an integral part of them. The most recent investigations and teachings of our acknowledged leaders in histology have reduced the typical idea of a cell to that of a mere concrete mass of "forming" and "formed material" (see note, p. 97 et seq.), but have not divulged anything new in regard to the vibrating *cilium*. It is now some five years since we ventured to announce our opinion that "*all vibratile cilia originate in the amorphous intercellular substance.*"[1] This has particular reference to those cilia that cover cells which are fully developed, and have a distinct cell-membrane. It would be true, as a matter of course, in the opinion of those who hold that Infusoria are composed of *sarcode*, but apparently untenable if we admit with Kölliker, which we do not, that they are unicellular. While we deny that these cilia are direct prolongations of the cells which they seem to be so closely related to, we do not assert that they are always disconnected with some form of cell in the modern acceptance of the ideal cell. We do, however, believe that they are never the filiform proliferations of a distinct cell-membrane, however much they may appear to be so, but that in such cases they arise from the cytoblastema which overlies the cells.

201 (A). We have now to offer new proof, supposing our observations to be correct, that the opinion announced in 1863 is a true expression of the relation of the vibratile cilia to the cells of the wall which they cover. Taking advantage of the profile aspect offered by the oöphragma (*figs.* 109, 110), as it curves over the rounded contour of the genitalia, we were enabled to view the bodies in question without any artificial preparation, such was the great range of adjustability of the objective used in this investigation. We wish particularly to observe here that the extent and thickness of the cytoblastemic intercellular substance in the oöphragma are rendered quite conspicuous by the abundance of granular matter (e^2 e^3) which is imbedded in it. By means of these granules we would, as it were, locate, relatively, the position of the swollen, knob-like bases of the cilia. These knobs vary in size and proportion to a considerable extent; some of them are scarcely wider than the cilium, while others are many times broader, with a proportionate length (*fig.* 112, E to K). They are usually longer than broad, and often elongate, oval, or fusiform (E K). In the latter case their points project to no inconsiderable distance downward between the cells. As far as we can make out, the larger proportion of the cilia arise at points alternate with the cells, but still, here and there, some overlie them. When the cilia become separated, as they readily do, from their attachments, the knobs may be traced to their direct transition into the filamentary part without any doubt as to their relationship. We have figured (*fig.* 112, E to K) several cilia in such a condition, not only from the oöphragma, but also from the gastrophragma, at a point near the edge of the

[1] See Proc. Boston Soc. Nat. Hist., Sept., 1863, p. 283; and Ann. Mag. Nat. Hist., Dec., 1864.

umbella. By fits and starts these were very active, moving rapidly by means of the *cilium.*

201 (B). We do not believe that it has been observed to what extent vibratile cilia are individualistic in their movements, at times, just as an arm or a leg is individualized. Cilia are commonly treated of like masses of men in an army, all moving to one determined end; as if the recorder of their movements did not think that the animal possessing them had the discriminating power of controlling the actions of any one separately. As well might one claim that the numerous legs of a Centipede are not capable of individual control. In contravention of such a mistaken assumption, we have been at some pains to illustrate the varying attitudes of the cilia (*fig.* 109, *w*) of the generative organ at a time when they were in a less active state than usual. Some of them project in rigid, straight lines from their bases; some again are straight at the base and undulating rapidly near the tip; others are in long curves from end to end, while here and there one vibrates in short, sharp curves throughout its length. These motions may be, by some persons, attributed to irritability, such as is often observed in recently killed animals; but the animal is fully alive in this case. We are well aware of the fact that we, ourselves, are unconscious of the movements of the vibratile cilia in our own body, but, on the other hand, no one, who is well versed in the habits of the Protozoa, will deny that the cilia and flagella of those creatures are to them what the arms and legs are to man. We claim, therefore, here, that the phenomena observed in Lucernariæ furnish just reason for assuming that the vibratile cilia are, at least in a measure, individually controllable.

It will be observed that our figures represent the cilia as having an equal thickness from base to tip. This we believe to be the fact in many other animals, but it is not generally so represented, because the tips of the cilia are usually so much more active than toward the base as to mislead one into inferring that they are thinnest there, since that part is not so easily detected.

201 (C). The *genital saccules* differ so little from the circumoral parietes in the histological elements of the walls, that all that is necessary to characterize them has been incorporated in the section (§ 18) where their general structure is described.

§ 26. *Histology of the Tentacles* (*figs.* 88, 89, 90, 91, 92, 93).

202. *The Ectophragma of the Tentacles* (¶ 96).—Notwithstanding the very extensive modifications to which this layer is subjected, in the different regions of the body, whether as the *ectophragma* proper on the posterior face of the umbella, or in the thickened peduncular disk, or as the thin *opsophragma* in front, or its prolongation on the shafts of the tentacles, or its great thickening mass on the globose tips of the tentacles, everywhere it retains its simple character as a *single stratum of cells.* No amount of differentiation, whether in reference to form or function, obliterates, or even disguises, that one unvarying, dominant character. These diversities are brought about by the least possible means; no repetitions, no circumambient or collateral appliances are connected with the pro-

cess. The means, as it were, become the end. In the globose tip of the tentacles each individual cell (*fig.* 88) constitutes the enormous depth of the layer at that point where it lies, and the expansion of the peripheral end of the same cell is the measure of the superficial extent of the spheroid at that point. We have already adverted (¶ 192) to an almost universal law among the *Acalephæ*, viz., that each cellular wall is composed of a single *stratum* of cells, but did not point out the inevitable result of such an arrangement, which is, as explained above, that organs are formed, not so much by peculiar modes of aggregating multiplied cells, as by varied modifications of comparatively few cells. This law becomes most prominent to the observer when studying the inherent characters of the cells themselves; and we then find that their essential qualities, such as they all have in common, are more or less inseparable from their modifications. One instance will suffice to illustrate this. The nucleus of the cells of the *opsophragma* occupies a corresponding position in all of them, so that in a profile view (*figs.* 88, 90, 91, 93) of the thickness of this wall the nuclei appear arranged in a single line, about halfway between the two ends of the cells; but where these latter are so modified, in the globose tip of the tentacles, that their depth is several times greater than their breadth, the row of nuclei (*fig.* 88, d^1) lies conspicuously near the peripheric end of the cells. Here the proportions of the form are not alone modified, but also the relative position of the contents of the cells.

202 (A). When we consider the extreme mobility of the tentacles, as exhibited in their powers of great elongation and high contractility, we cannot avoid inferring that their component cells are adjustable in a commensurate degree between the limits of these changes. This observation proves to be true; but we could hardly foresee that, besides varying in form, they would, at times, arrange themselves, or rather perhaps allow themselves to be arranged, in definite lines, or rows, corresponding to the trend of the muscular fibrillæ which underlie them. In a word, we find that when a tentacle is contracted, the cells of the *ectophragma* not only are broader in the direction of the contraction, so that their major diameters trend parallelwise with each other, and consequently with the axis of the tentacle, but they are also arranged in lines (*fig.* 92, *d*) more or less regular, parallel with the muscular fibrillæ (m^2) (¶ 98), and usually alternate with them, the latter being slightly imbedded between the ends of the former. Now it would seem as if the contraction of the whole mass would tend to compress the ectophragmal cells, so that their major diameters would trend transverse to the axis of the tentacle, but as it is not so we must infer that the lateral pressure is greater than the longitudinal, yet we have to account for the linear arrangement of these cells, and their evident connection, in this respect, with the muscular fibrillæ. It would seem plain enough that when these fibrillæ contract they must of necessity decrease the diameter of the adjoining cells, in the same direction as the contraction, and throwing them sideways against each other, mingle them promiscuously; but we should not overlook the fact that as a muscle contracts it broadens, and hence it will exert a lateral pressure, and in doing so it will force the neighboring cells to arrange themselves in lines on each side of it.

We must also take into account the fact that the force of contraction operates upon the cells, not exactly parallel with the axis of the tentacle, but obliquely to it, *centrifugally*, and hence, as a proof of it, we find the same cells, which were not quite twice so deep as broad when the tentacle was extended (*fig.* 90, n^1), are here (*figs.* 92, 93) at least five times deeper than broad, that is, they are very narrow, and moreover, from mutual pressure, prismatic in appearance, when viewed in a body.

202 (B). It is well worth while to observe that, when these cells deepen, the change appears to be confined mostly to that region which lies between the nucleus (d^1) and the end next the muscular fibrillæ (m^2), while the modification at the other end consists of little else than a narrowing in one direction, and a broadening at right angles to that. Why the nucleus marks these limits we cannot conjecture; and although it may be readily understood why the cells should deepen more at the proximal end, that being nearer in the line of the pressure induced by contraction, there is no apparent reason why there should be such a sudden change on the distal side of the nucleus, where the depth increases very little. When the tentacle is fully extended the nucleus (*figs.* 90, 91, d^2) of the ectophragmal cells is a little nearer to the distal than to the proximal end. Between this condition and that of extreme contraction of the tentacles there are to be observed all possible grades within a short space of time; there is no absolute standard of proportion in any part of the shaft of these organs. In their spheroidal tips, however, the cells of this layer (*figs.* 88, 89) seem to have been crystallized, as it were; fixed within extremely narrow limits of change, and varying but slightly in depth, which is to their average breadth as five or six is to one. But of this we shall speak hereafter more in detail.

202 (C). *Contents.*—The ectophragmal cells of the shaft (*figs.* 90–93, n^1) are very transparent, not only as regards their contents (d^2), which are perfectly homogeneous, but as to their walls (d). The latter are moderately thick, evidently; although it is quite difficult to detect the line of mutual apposition of adjacent walls, which is still more uncertain at those places where interstitial granules (e^2) are crowded between them, or overlie their peripheric or proximal ends. Beside this very abundant and more or less highly colored, interstitial, granular substance, there are scattered here and there, quite rarely, isolated *nematocysts* (l). The *nucleus* (d^1) lends little or nothing to the color, as it is of a grayish transparency; but still, it is readily detected, on account of its peculiar, soft, semi-opacity. It is rather oval than circular in profile, and might be compared to a slightly flattened disk, attached by one of its faces to the cell-wall. Its greatest breadth is fully three times the thickness of that wall.

203. *The ectophragma of the spheroidal tip* (nematocystophore) of the tentacles presents some peculiar modifications not to be found on the shaft. This is the part which is formed first (*figs.* 58, 59, ϕ^2) in a young tentacle, and may be recognized, even before the organ amounts to more than a mere papilla, by an accumulation of numerous nematocysts imbedded in the interstices of the cells, and also by an extraordinary deepening of these cells, so as to give an abrupt increase to the thickness of the layer. Even at this early period the cells are three or four times deeper than broad, and they continue to develop in this respect until the tentacle is full

grown, when they may be found measuring in depth several times the breadth (*figs.* 88, 89). As to form, the main peculiarity of these cells in an adult tentacle lies in their gradually widening calibre, which is narrowest at the proximal, and broadest at the distal end. On the whole, then, each cell has the form of a very elongated, prismatic conoid, inverted on its apex; but it is so modified by the lateral pressure of the interstitially imbedded nematocysts (l, l^1) as to be more or less irregular in shape. They differ also from the cells of the shaft in having a very narrow range of mobility; in fact they are comparatively fixed, and not subject to wide changes in form as the tentacle expands or contracts. They differ, again, in the position of the *nucleus* (d^1), as that is attached much nearer the distal end. They are, besides, more considerably modified in form by the greater amount of granular interstitial matter (e^2), especially between their proximal basal ends. This is so abundant in very old tentacles as to render their tips nearly opaque; and, as it varies in color, like the pigment masses in other regions, it gives varied hues to the globose mass.

203 (A). *The interstitial cytoblastema* merits particular attention here, on account of its specialized condition. We have just spoken of the mass of pigment granules in its proximal side, about the bases of the cells; but here we wish to draw attention to its exclusive devotion, at the distal side, to the formation and development of *nematocysts.* Not only do these cysts (l, l^1) originate in it, and remain imbedded there, sometimes considerably below the general surface of the layer, thus giving to the *cytoblastema* a specialized character in this region, but they also involve it, indirectly at least, in the apparatus of prehension. We refer here to the bristling points (*fig.* 88, e^1), which are so numerous on the surface, standing singly in the intervals between the cells. From many points of view they project as if in direct prolongation of the axis of a nematocyst; and frequently, when the shaft of the latter is partially everted, it seems to be the cause of the bristling, appearing to push the plastic blastema before it until it is forced out into a fine point. But that this is not so is shown by the fact that these bristles still continue to project, while the nematocyst is completely closed (*fig.* 88, A). They may have been formed originally under the influence of the nematocysts, and then retained the form imposed upon them; but that partakes too much of the mechanical in its method, and makes them appear as if the mere accidents of contiguity. Moreover, if they were so formed, they ought to stand directly in the way of the shaft of the nematocyst when it protrudes; but they do not, and so far from it that each bristle stands more or less to one side of the shaft when that is out, and sometimes, even, at a greater distance when the same is retracted. These facts may be more easily elucidated in common fresh-water *Hydræ* than in *Lucernariæ.* We are, therefore, rather disposed to think that they were developed, just as the parts of the thread of the nematocysts were, in place. Their connection with the prehensile organs, functionally considered, it is true, is inferred mainly from their occurrence only where these organs exist, but we think that that is enough to show at least their architectural relations. Their one-sided, asymmetrical form, added to their lateral position, suggests strongly that they possibly may perform the office of valves or lids; but on the whole we believe them to be *tactile bodies*, standing sentinel at

the doors of the nematocysts, to give warning of the approach of any foreign body.

204. *Muscular Fibrillæ* (¶ 98) (*figs.* 91, 92, $1m^2$, $2m^2$, $3m^2$).—Notwithstanding that these fibrillæ exhibit a quite marked tendency to arrange themselves in fascicles, as if to form a distinct organ, like that in the peduncle (¶ 59, 88, 199), we meet with no trace of intermixture of such cells as are so abundant in the latter. The fibrillæ of the tentacles are remarkably distinct from all surrounding tissue, both as a whole and as regards their component elements, the elongated, fusiform cells. Their only connection with the ectophragma (n^1), on the one hand, and the chondromyoplax (b^1) on the other, is that of mechanical contact. They are buried mostly in the peripheral surface of the chondromyoplax (*fig.* 91, b^1), and very slightly impress themselves on the inner face of the ectophragma. The cellular elements of a fibril are not so clearly apparent from that point of view which regards them face-wise, *i. e.*, looking in a line perpendicular to the layers of the tentacles, as they then seem organically united with each other, end to end, and do not allow their lines of junction to be seen. Taken together, then, they form an undulating thread, which is slightly swollen from point to point, with a faint elongated nucleus occupying a large part of the length of each swelling. That these swellings correspond to individual cells, each containing a single nucleus, may be proved by obtaining a view at right angles to this, that is, observing them in profile (at $1\ m^2$); when they will have all the appearance of a linear series of separate, fusiform bodies, overlapping each other at their pointed ends. From this point of view, and in a transverse section (*fig.* 91, m^2) also, we can determine most satisfactorily that the fibril cells have no organic connection with the chondromyoplax (b^1). The amorphous, rigid fibrillæ of the latter abut at their broader ends with a most decided line of separation between them and the fusiform cells of the muscles. The two have nothing in common, unless it be the intervening blastema which constitutes the mould in which all cells are cast. (See ¶ 196.)

205. *The Chondromyoplax* (¶ 196) (*figs.* 90, 91, b^1).—In immediate connection with what has just been said, incidentally, in regard to this layer, we have only to add a few words, particularly in reference to the function it possesses in the economy of the organ to which it belongs. When discussing its qualities as a layer (¶ 65, 196) in the front of the umbella, we argued that it had rather the function of elastic connective tissue, without saying precisely how it operated. In that position it would more likely be subjected to traction than to compression, or at least to a much greater degree. There can be no hesitation in deciding that in the tentacles it acts as a resilient body, in counteracting the retractile force of the muscles, and repressing, to a certain degree, the expansive force of water injected into the tentacle from the main cavity of the body. Its prime value, however, is felt when, by its great resiliency, it extends the tentacles to their extreme length. There are no annular muscles in these organs, and their longitudinal fibres can only retract them, or flex them from side to side. The histological elements of this layer are the same as in the umbella, and, as they have been described (¶ 196) pretty fully in that connection, we will not repeat the description here.

The position of the fibrillæ, however, needs special mention. They hold the same general relation to the adjoining layers as in the umbella, but in the latter they all point or trend one way, *i. e.*, antero-posteriorly, while in the tentacles they vary, not in reference to the ectophragma and endophragma (gastrophragma), but following the curvatures of the latter as they form the hollow shaft, they always trend in the direction of the radii of these curves. As a consequence of this, then, their trends radiate from the axis of the shaft, except at the tip of the organ, where the layers converge and form a series of superposed hollow hemispheres, and there the trends of the fibrillæ radiate as if from the centre of a sphere. Their trend in the *intertentacular lobules* will be best comprehended in connection with the description of the morphology of these bodies, to be found in a previous paragraph (¶ 103).

205 (A). Over a greater part of the regions in which the chondromyoplax prevails its fibrillæ abut at right angles against the adjoining layers, but at the bases of the tentacles their disposition is modified in a marked degree, in connection with the peculiar arrangements of the muscular layer. The latter, as described in a former paragraph (¶ 82, 100) with considerable detail, passes obliquely from the periphery to the inner layer, or gastrophragma, forming a partition (*fig.* 60, k^1) between the chondromyoplax (b^1) and the edge of the chondrophys (c). The fibrillæ of both these layers abut against this oblique partition, at very acute angles, their proximal ends being based on the gastrophragma (i, i^2). This we should say, also, takes place along the whole circuit of the edge of the umbella, wherever the chondrophys and chondromyoplax adjoin a common area of termination.

206. *The Gastrophragma* (*endophragma*) (¶ 101) of the tentacles (*figs.* 90, 91, i^2). This single *stratum* of cells owes its great thickness only to the extreme depth of the latter. It varies considerably according as the tentacle is extended or contracted; in the former case the cells, lessening to their minimum depth, are still three or four times deeper than broad, and in the latter case they have a much greater measurement. They do not, therefore, exhibit that wide range of variation in proportion which the cells of the ectophragma (n^1) of the shaft do, but have rather the approximate fixedness of those of the globular tip; and, as they are not so irregular in outline at the sides, they are more prismatic in appearance. In a profile view (*fig.* 90) of a tentacle these cells present parallel sides, but in a cross sectional view (*fig.* 91, i^2) of this organ, they very naturally, from being arranged radiatingly about an imaginary axis, appear narrowest at their proximal ends, and gradually expand, wedge-like, to their distal terminations. They are not, though, four-sided, as these two views might, perhaps, lead us to suppose, but irregularly polyhedral, varying from three to six sides, as may be learned by looking at them endwise (*fig.* 90, 1 i^2). Their walls are about as thick as those of the ectophragma (n^1), and, like those, very sharply defined within, but rather obscurely without, either because they are overlaid by the intervening pigment granules (c^2) about their proximal halves, or from being more or less organically united along their lines of contact, at their distal halves. The rigidity of a prismatic conformation is negatived by a long undulating contour, which rather enhances, than lessens, the brilliancy, by the ever-varying surface which the walls

present to the eye. By contrast, also, these cells are apparently endowed with a superabundance of light. Their contents (d^2) are perfectly homogeneous and transparent, and therefore the deeply-colored nucleus (d^1) is rendered highly prominent, both from its isolateness as well as from its marked difference in refraction. We are reminded, in this respect, of the intensely brilliant cells of the gastrophragma in the peduncle (¶ 200).

206 (A). The *nucleus* (d^1) is not in itself so deeply colored, but is irregularly coated by an accumulation of dark, fine, granular matter; and that, at the same time, gives it a jagged appearance. This is a peculiarity, though not so strong, which it has in common with the nuclei in other parts of the body, as in the endophragma of the peduncle and the anchors, and in the ectophragma of the aboral side of the umbella. Its true form and aspect are identical with those (¶ 205) of the ectophragma of the tentacular shaft. The position of the nucleus is the same as in the ectophragmal cells (*fig.* 88, d^1) of the spheroidal tip, *i. e.*, it lies nearer the distal than the proximal end, or about half-way between the end and the middle of the cell; and thus all the nuclei, taken together at one view, appear to stand in an irregular row, parallel with the surface of the layer which they compose. It differs, though, in one respect, in that it is nearer the attached than the free end of the cell, which is the same as in the gastrophragma of the peduncle (¶ 200). We have stated in another place (¶ 36) that the pigment is uniform in color throughout the body, and therefore the color of the nucleus, or rather its granular envelope, corresponds to the prevailing tint.

206 (B). The *intercellular pigment* (c^2) of the gastrophragma merits pointed attention here, not so much because we have any positive function to assign to it, as for its peculiar constitution. It has been customary among physiologists to attribute a biliary function to any highly colored, especially brownish, masses of irregular cells or cell-like bodies, if they coat the inner face of the digestive cavity. Now if, instead of finding in the hollow of the tentacle such a dense coating of pigment-like, and even cell-like bodies, we met with it on the inner face of the general cavity of the body, it would be very natural to surmise that its components might possibly possess a glandular nature, perhaps biliary, or even urinigerous. Since, however, they are comparatively scant in the latter region, we guess nothing of the kind; and as such functions would appear out of place in a tentacle, we have no such teleological appliances to thrust in there, nor any other, inasmuch as these granules present no obvious use. It is true that some seem to possess a transparent envelope, which gives them a marked cell-like appearance; but in this respect, as in all others, they are, like those which embrace the proximal ends of the ectophragmal cells (*fig.* 88, c^2) of the spheroidal tips, buried deep in the thickness of the tissue.

§ 27. *Histology of the Colletocystophores* (*Anchors*) (*figs.* 47, 82, 83, 94, 95, 96, 97).

207. *General Features.*—Both in an histological as well as in an organical point of view the fully grown *colletocystophore* is divided into three distinct regions, viz., the pedicle, the nematocystophore, and the colletocystophoric mass. In the young

(¶ 166–173), these areas are more sharply defined in external appearance, but they do not attain to a well-marked histological differentiation until a late period. It is true that the colletocysts appear as soon as a change commences on the tentaculoid shaft, but the corresponding changes in the interior walls are not completed until the animal is probably two-thirds developed in size.

208. The *Ectophragma* (Opsophragma) of the *colletocystophore.* In the earliest stages the cells of this layer are identical with those in the shaft of a tentacle, but they soon lose this character, and become gradually, yet rapidly, very deep and prismatic (*figs.* 82, 83, a^3), like those in the globose nematocystophore (a^2), and, at the same time, adherent vesicles (a), the *colletocysts*, originate and develop in their interspaces. This process goes on until, as described in the previous paragraphs (¶ 160–173) on embryology, the whole shaft is metamorphosed into a thick, pad-like mass of very deep, prismatic cells and imbedded colletocysts. These cells vary considerably in depth in different parts of the full-grown organ (*fig.* 47, n^2), yet they are not subject to changes in length and breadth to any very appreciable extent, since the colletocystophore is relatively far less expansile and contractile than the tentacles. They are most closely allied in form and proportions to those of the globose tip (nematocystophore) of the tentacles, but they are not so tapering and conoid, since they are arranged in a layer which has a much broader curve, and consequently they approach more closely to a strictly prismatic form. They are conspicuous for their large and dark nucleus-like body (*fig.* 97, d^1), which is in reality a mass of pigment-granules enveloping a transparent, single nucleus. In this respect they resemble those of the gastrophragma (*figs.* 94, 95, d^1) of this organ, but the nuclear-body is not near as large in the former.

208 (A). The *intercellular colletocysts* (*figs.* 96, 97, a) modify the arrangement of the cells of the ectophragma more extensively than do the nematocysts in the tentacles. They lie not strictly in the intercellular spaces, as they are much larger than the cells, but, as it were, on the top of them, in a hollow or deep depression, sunken in the layer. These pits (*fig.* 96, a^1) contain from one to three colletocysts (a), and occupy more space than the areas between them. Still this does not appear so, because the ends of the surrounding cells curve inwardly so as to partially cover (*fig.* 97) the colletocysts, and thus form, collectively, a narrowed entrance to the pit. This arrangement leaves a part of each colletocyst naked, and ready to adhere to any substance that may come in contact with it. Whether the animal has the power of opening or closing the aperture of the pits, and thus varying the breadth of the adherent surface of the colletocysts, we cannot say; but if it be so, it must be done indirectly, because there is no contractility in the cells themselves. It is possible, however, that the underlying cells may be forced up by the action of the muscular layer beneath them, and that the colletocysts be protruded through the aperture of the pits. As the colletocysts are colorless, the granular intercellular bodies and the pigmented nucleus of the cells constitute the coloring matter of the layer. The structural details of the colletocysts are to be found in a separate section, or the prehensile organs (§ 30). Occasionally we have also met with nematocysts (l) intermingled with the colletocysts, but as they are rare, and usually

quite small, we judge that they are not of special importance in this region, but rather remnants of an embryonic condition.

208 (B). The colletocystophoric *nematocystophore* in its earlier days has all the proportions in shape and numbers of that of a true tentacle of the same age; and in fact the one could not be distinguished from the other if detached from the body so that their position might not be known. At that period they seem to be of equal value as prehensile organs, but in course of time, as the colletocysts progress in development the nematocysts decrease in number, and the layer in which they are imbedded grows less in thickness. Still as the change is not abrupt but gradual, we should judge from appearances that the nematocystophores retained their power largely until the body had grown to from one-quarter (*figs.* 82, 83, 84) to one-half its adult size. In the full-grown condition (*fig.* 47), at last, we find a mere remnant (a^2), and so faint as to readily escape notice. The nematocysts are relatively very few, and the layer of prismatic cells is a meagre representative of what it once was, a slight knob or undulation on the surface of the semi-transparent area, peculiar to that region of the colletocystophore.

209. The *opsomyoplax* (*fig.* 47, m^3) of the colletocystophores offers nothing peculiar, or different histologically from what may be observed in the tentacles, but as to the arrangement of the muscular fibrils there is a marked diversity; yet as that has been given with sufficient details in the general description (¶ 105, 111) of the layers we will not repeat anything here.

210. The colletocystophoric *chondromyoplax* (*fig.* 47, b^2) does not seem to differ from that in the tentacles (*figs.* 90, 91, b^1), as far as its *histological* elements are concerned; not even after it has been so irregularly disposed, as to thickness, as we find it in a fully developed anchor (see ¶ 112). The more or less abruptly changing diversities in the depth of this layer are accompanied by as abrupt shortenings or lengthenings of the fibrils, but not by any other modifications that we could discover.

211. The *gastrophragma* (*figs.* 47, i^1, 94, 95) of the anchors embodies the most remarkable modifications of cells, excepting the nematocysts and colletocysts, that we have met with in this animal. Yet, as will be seen presently, traces of what here amounts to a singularity are to be found in other parts of the body, both without and within; and serve to clear up what appears to be at first glance a strange anomaly. In the depths of the cavity of this organ the gastrophragmic cells are from three to four times deeper than broad; and on the whole may be set down as prismatic in contour; each prism occupying the whole depth of the layer (*fig.* 94, A, B). The wall (*d*) of each cell is quite thick, especially at the ends, and perfectly transparent and homogeneous in texture; but it varies in thickness in a most remarkable way, however. This consists in an internal annular thickening of the wall at two points so disposed as to divide the cell into three equal regions. The annular semipartitions are broad at the base, but rapidly run out to a sharp edge, which sometimes projects one-quarter the distance across the cell-cavity, but usually less than this amount. This reminds me of a cell undergoing self-division; and the disposition of the contents seems to bear out the analogy; but although rarely, here and there, one of these dark internal masses is

divided into three distinct portions (A), we have never been able to find a true, undoubted cell-multiplication. The peculiar disposition of the contents is as singular as the modifications of the wall; and it seems to be strictly in accordance with the latter. It would appear that the same influence which produced the annular semipartitions also affected the dark, innermost, pigment mass (d^1) in such a way as to constrict it exactly opposite these annuli; but yet not by the direct impression of the latter upon the former, for a considerable clear, transparent layer (d^2), forming the periphery of the contents, intervenes. If, therefore, there is any impression transmitted it must be through the latter layer. Laying aside, now, this rather mechanical, physico-motor explanation, which we have used merely as a matter of convenience, and not to illustrate any real series of sequences, which might be supposed to arise the one from the other, we will state, in brief, our conviction that the cell-contents have, by an inherent property, assumed the subdivided form which is presented there, and that the *annuli* of the wall are rather formed last, and probably deposited from the surface of the contents.

211 (A). As we recede, now, toward the entrance to the cavity of the colletocystophore, we actually advance toward an explanation of the nature and origin of these singular contents. Gradually the layer grows less and less in thickness (A to D), and the component cells decrease at a corresponding rate in depth. But we particularly note that the annular semipartitions gradually lower their ridges, and the constrictions grow shallower until both disappear by the time we arrive at those cells which are about as deep as they are broad (D). The innermost dark pigment mass yet consists of very large, closely-packed, irregular granules, but rather smaller than in the thickest part of the layer. From this point, still receding, the dark mass grows proportionally less, and the clear contents correspondingly greater (*fig.* 95, d^2), while the cell bodily shallows down to near the proportion of dermal epithelium (C). In the latter condition the dark pigment-mass appears, in a profile view, like a thin streak in the middle of the cell, but in an end view it has the appearance of an irregular nucleus (*fig.* 95, d^2), being in reality nothing more nor less than a nucleus covered by a coating of pigment-granules, as we have described in the ectophragma (¶ 194) and other places. Now, if there be any part of the cell that influences internal changes more than another, it certainly is where the nucleus usually appears; and we consider the nucleus to be the expression of an intensified concentration of cell-power, and not an isolated body, as it is usually described. When, therefore, the dark pigment mass accumulates in all the intervening space between the nucleus and the extremities of the cell cavity, we do not suppose that it gradually thickens as a coating over the nucleus, by any condensing power of the latter; but that it develops in mass under the all-pervading cell-power which radiates, as it were, from one point of greatest intensification. In this way we may explain the final appearance of the constriction of the dark mass, and the annular semipartitions of the wall. These peculiarities could no more be produced by the operations of an isolated body at a distance, a self-contained nucleus, than could the analogous changes which eventuate in the appearance of the spiral coil of the nematocyst (*figs.* 135–145). It will be apparent enough, without further explanation, that

the great depth of color of the anchor is due largely to these enormous masses of intra-cellular pigment. The tint varies in different individuals, but is uniform, with varying intensity, in the same body, the latter being either altogether green, or orange, or purple, or blue, etc., and not a combination of any of these colors; but sometimes is apparently so, as, for instance, when a light purple or violet umbella seems to have black anchors, the latter, though, when examined under a slight magnifying power, turning out to be of an intense, concentrated, dark purple. Notwithstanding the remarkably abrupt changes in depth which the gastrophragma exhibits at irregular intervals throughout the colletocystophore, the component cells neither increase nor decrease in numbers, but always remain combined in a single *stratum*, simply varying in depth according to the greater or less abrupt thickenings or thinnings of the layer (see ¶ 113).

§ 28. *Histology of the Caudal Disk* (¶ 115). (*figs.* 118, 119, 120).

212. *The Ectophragma* (¶ 63, 194).—Since this is the only layer which is modified differently from those of the peduncle proper, which are described in a previous section (§ 25), we shall confine ourselves to it alone. As in the anchors, so here the cells are prismatic in form, but proportionately much broader and exceedingly small, when contrasted with those of the former. Their share, though, in the formation of the layer is considerably less, because they are obscured and overlaid almost entirely by the nearly close ranks of colletocysts and nematocysts; in fact, a profile view of a section of this layer (*fig.* 118, f^1) presents the appearance of being composed, at least for two-thirds of its depth, almost entirely of these two last-mentioned bodies (*a*, *l*). A face-view (*fig.* 119) is, therefore, a much better exemplification of the true state of relationships here. By that we learn that there are but very narrow areas, next the outer surface of the layer, which are occupied by the normal, prismatic components of the layer, and the rest is filled up by irregularly alternating colletocysts (*fig.* 118, *a*) and nematocysts (*l*). The inner third of the layer is purely cellular, and the outer or distal two-thirds is compounded as described above, yet still there is but one *stratum* of cells proper; those alternating with the imbedded bodies being the longest, and extending from the proximal to the distal surface, and those overlaid by the nematocysts and colletocysts abutting against the latter with their distal ends. The *colletocysts* (*a*) are not more than one-tenth or one-eighth the diameter of those of the anchors (*fig.* 97, *a*), excepting here and there a few of equal size, but they are far more closely packed together, and thus make up in point of numbers what they lack in size. They are treated of *in extenso* in the section on the prehensile organs (§ 30). The *nematocysts* (*l*), which serve to partly fill up the intervals between the colletocysts, are excessively small, and hardly recognizable as prehensile organs of that kind; but they are conspicuous simply because they are numerous, although looking more like granules than urticating organs under a magnifying power of several hundred diameters (*figs.* 118, 120, *l*).

§ 29. *Histology of the Digituli* (¶ 52, 116–121) (*figs.* 98, 99, 100, 101, 102).

213. *Topography.*—In the general description of the walls (¶ 116–121) of the digitiform bodies we have, unavoidably, entered so far into the consideration of their histological elements that there is but little to add here. The disposition of these elements, whether they be true cells or fibre-like in character, is so thoroughly intermingled with the topographical apportioning of the several layers and their subdivisions, that any attempt to describe the latter without including the former would utterly fail to present a picture of the nature of these organs, beyond a mere idea of their outlines. We will not, however, repeat here what has already been given so fully, but beg our readers to consider § 15 and the present section as one, for the time being. In regard to a single point in the paragraph (¶ 117) which concerns the relative positions of the nematocysts and the colletocysts on the supposed flat sides of the *digituli*, we would add one more fact, without commenting upon its significance, if there be any. We refer to the corresponding position of the vibratile cilia (*figs.* 98, 100, *co*) with those on the genital organs, the areas of both facing in the same direction in a general way; whilst the area of the colletocysts (*a*) corresponds to that in the genitalia which bears the layer of reproductive bodies, either eggs or spermatozoa.

214. *Gastrophragma of the Digituli* (i^{s}).—Within the area which is covered by the colletocysts (*a*) the latter occupy about four-fifths of the space, and the true cells the rest, filling up the intervals; while, on the other side, the nematocysts (*l*) are set quite wide apart, and are a subordinate feature in the composition of the layer. In a profile, sectional view (*figs.* 99, 100, *a*) of the wall in which the colletocysts are imbedded, the latter appear to constitute the whole layer, so nearly obscured are the cells by these densely packed vesicles; yet, from a face-view (*fig.* 99, 1*a*, *fig.* 101), we learn that the cells do actually form a continuous *stratum*, but so thoroughly intersected by the vesicles that it has the appearance of a network of a single, or more or less double, row of cells.

Whether on the side of the nematocysts, or where the colletocysts prevail, the cells of the gastrophragma (*fig.* 101, i^{s}) have the same structure and contents. They are by far the smallest of those that belong to this layer in any part of the body, but they have the same elements. There is the same clear homogeneous contents, and a like single nucleus, so encrusted by pigment-matter that the mass occupies from one-third to one-half the diameter of the cell. It is a notable fact that none of these cells underlie the colletocysts, as they do in the ectophragma of the colletocystophores (¶ 208 (A)), and for this reason, that the colletocysts of the *digituli* extend through the whole depth of the gastrophragma, and abut immediately against the muscular layer; and in a measure adhere to it. In regard to the latter statement, we will say, in passing, that the colletocysts are the last to break away from the underlying tissue when the layer is disorganized by the application of fresh water (*fig.* 103, *a*); and they seem to be organically attached by a narrow, short stem or neck to the muscular layer (*a*). In point of size they are quite diminutive, not more than one-quarter the diameter of those in the colletocystophore (*fig.* 97, *a*), and yet about three times the diameter of those in the peduncular disk (*figs.* 118, 120, *a*). The *nematocysts* (*fig.* 100, *l*) also occupy the whole thickness of the gastrophragma. As to the vibratile cilia (*fig.* 100, *co*) we have only to add that they are unusually long, and very thickly set together.

§ 30. *The Prehensile Cysts.* (*Nematocysts and Colletocysts.*)

215. *The Nematocysts* (Pl. XI, *figs.* 133 to 145).—These bodies have been so frequently described and so fully illustrated of late years that we do not expect, here, to add materially to the knowledge of them, as far as their general structure is concerned. We merely present some new forms, or at least new variations of the type, from a hitherto unknown source. In an article, which we published under the title of "*Lucernaria the Cœnotype of Acalephæ*," in the American Journal of Science and Arts for May, 1863, p. 346, there is a note appended, on p. 352, which is devoted to a concise description of the two kinds of nematocysts that are common to *Haliclystus auricula.* We propose to reproduce that note here, with some few additional remarks, and a number of illustrations. That nematocysts have an *inter*-cellular and not an *intra*-cellular position we think has been made sufficiently manifest when describing the cellular structure of the outer wall (opsophragma) of the globular tip (nematocystophore) of a tentacle (see ¶ 203, 203 (A)). We have recorded our opinion elsewhere (Proc. Boston Soc. Nat. Hist., Sept. 16, 1863, p. 283, in note) that they also have an inter-cellular *origin*, and do not develop within the cells which form the layer in which they are imbedded, but commence their career, *de novo*, by free cell formation in the cytoblastema. Their relation to the cytoblastema is curiously illustrated in another way; we refer to the supposed "tactile bristles," which have been described quite fully enough, probably, in a former paragraph (¶ 203 (A)). Their presence there, and nowhere else, seems to show a more intimate relationship than usual between the cytoblastema and the cells; and points argumentatively to the agency of the same cytoblastema in that shaping out of the nematocysts.

216. A *nematocyst* of the larger kind (*figs.* 133 to 141), belonging to the tentacles, consists of an oval, thick-walled vesicle (*fig.* 134, *cl*), about $\frac{1}{2000}$ of an inch long, or a little less, one end of which is introverted, and projects, in the form of a stout hollow shaft (*sl*), along the axis of the cell, about four-fifths of its length, and then, rather suddenly thinning into a slender thread (*tl*), which also is hollow, it bends upon itself, returns nearly to the aperture (*ml*) of the cell, and again receding and pressing closely against the inner face of the cell-wall, it forms there a close coil (*lc*), which terminates at the end opposite the mouth (*ml*) of the introversion. In a younger and smaller cyst (*fig.* 133) the shaft (*sl*) extends from the aperture almost to the opposite end, and then the thread proceeds to coil up as in the fully grown. The spiral ridges apparently on the shaft of young specimens are formed by rows of bristle-like bodies which are packed closely together, and overlap in the hollow of this introverted body. In an old cyst the separate bristles may be seen in place, while the cell is closed (*fig.* 134), but it requires very careful research.

When the coil of thread is ejected (*fig.* 139, *tl*), which is accomplished by sliding through the hollow axial shaft (*figs.* 135, 136, 137), which in its turn retroverts also, just as the finger of a glove is turned inside out, the whole aspect of the apparatus is changed (*fig.* 139). The oval cell (*cl*) is considerably diminished in size, and from its aperture (*ml*) the more enormously enlarged hollow shaft (*bl*, *dl*) projects in a straight line; the part of the shaft next the cell is cylindrical (*bl*), and half as broad as the latter, with a slight expansion where it joins the mouth of the cell; the distal half abruptly expands into an oval form (*dl*), half again broader than the cylindrical portion, and rapidly tapers into a smooth, trihedral, twisted thread (*fig.* 141, *tl*). The oval part (*dl*) of the shaft is endowed with three equidistant spiral rows of setæ, which number about a dozen in each row. The setæ are comparatively large, and in length equal two-thirds the broadest diameter of that part of the shaft from which they project. Each row makes but one turn about the shaft, and terminates as if in continuation (*fig.* 141) of the angles of the trihedral thread. There is not the least trace of setæ or projections of any kind upon the trihedral thread, but it continues, with a very gradual taper, perfectly smooth, to a blunt termination. The angles (*fig.* 141) of the thread appear, at first glance, as if they might be spiral rows of setæ, but a most careful and prolonged examination, with one of Spencer's $\frac{1}{8}$ inch objectives, convinced us that they are truly the angles of a twisted trihedral filament. The extent of the thread is from twenty to twenty-four times the length of the cyst. That the thread and shaft are not ejected by a breaking open of the cyst, as some have asserted, we present proofs like those given by other authors, but particularly valuable on account of the distinctness of the several regions of the shaft and the thread during retroversion. In *fig.* 135 the proximal or basal half of the shaft (*bl*) only is everted, and stands out clearly from the distal portion (*dl*) which remains within it. In the latter the spiral rows of setæ are packed down one upon another so as to form ridges. The thread (*tl*), of course, is slightly drawn out of the cyst into the basal portion of the shaft. In figure 136 the whole shaft is everted, and has its characteristic form, but the thread still remains within, extending back, in a winding course, through the hollow of the shaft into the cyst, where it lies in looser coils than in a perfectly closed organ. The next figure (*fig.* 137) illustrates the expansibility of the thread itself (*tl*). In order that its distal or free portion (B) may slide through the bottom of the basal part (A), the latter must dilate until its calibre is at least equal to the diameter of the former. But it does even more than that, as the figure (*fig.* 138), of diagrammatic size, shows, for there the calibre of the everted portion (A) is large enough to allow the rest (B) to wind through it in a zigzag course. As is perfectly clear by the figure (*fig.* 137), but a small part is everted, and the remainder, after winding back through the shaft, is loosely coiled up in the cyst. It is a noteworthy fact that, after the thread is wholly everted (*fig.* 139), the cyst does not close its aperture. Whether this is due to a certain inherent resiliency in the region where the shaft is attached, or results from the contraction of the cyst upon the contained fluid, tending to force it outward, but restrained by the closed hollow of the thread, we hesitate to decide upon. Since we have frequently seen a cyst rapidly diminish in size upon the sudden ejection of the thread, although it lay free in the field of the microscope, it is plain enough that it is self-contractile. As we are not in the habit of using that dangerous instrument, the *compressorium*, we have no allowance to make for mistakes in that direction. Whether a thread, after being once ejected, is ever retracted into the cyst again remains as yet undetermined by observation, but the circumstances of its eversion render it highly probable that it is not.

217. The *smaller nematocysts* (*figs.* 142, 143, 144, 145) are much more simple in structure than the larger forms, but remarkable in other respects. The introverted shaft (*fig.* 142, *sl*) is very slender, in fact no larger than the rest of the thread. It does not project into the axis of the cylindrico-oval cell, but presses close to its side, and extends four-fifths of the way to its opposite end, and then, bending abruptly upon itself, the thread passes with a long curved sweep nearly to the aperture of the cell, whence it again returns with another long sweep, which is repeated eight to ten times (*figs.* 143, 144), until the inner face of the cell-wall is lined by a close coil (*lc*), which winds lengthwise, instead of transversely, as it does in the larger nematocysts (*fig.* 134). When extended (*fig.* 145, *tl*) the thread is from twelve to fourteen times the length of the cell; and it offers not the least sign of appendages of any kind, but is simply a smooth, round filament, of uniform thickness throughout, except at the end, where it tapers slightly and terminates in a blunt tip. The cell itself, when everted, is sensibly diminished in size, and narrows rapidly into the prolonged filamentary portion. Both of these kinds of nematocysts, and these only, are found in other parts of the body besides upon the tentacles, but they vary a great deal in size, and in some cases are very small, as, for instance, in the adherent disk of the pedicle. Möbius has favored us with a copy of his memoir (*Ueber den Bau*, etc. etc., *der Nesselkapseln*, etc.; Abhandl. des Naturwiss. Vereins zu Hamburg; Erstes Heft, des fünften Bandes, 1866) upon these bodies, in which he claims that the shaft is closely invaginated upon itself, when the cyst is closed. We have not had an opportunity of looking at this point since the reception of the paper. If it be true, it seems to explain the sudden jerk with which the shaft of the nematocyst is often everted, as if with explosion. This is remarkable in the cysts of Hydra.

218. *The Colletocysts* (*figs.* 96, 97, 101, 102, *a*, a^2).—The discovery of these bodies added a third kind of prehensile cyst to those so well known among the Acalephæ and Ctenophoræ. Ehrenberg recognized the office of the nematocyst (Abhandl. Berlin Akad., 1835 [1837]), but we owe to Doyère (Compte Rendu, Août, 1842) the original solution of its structure, as an invaginated, hollow thread within a cyst of which it is a direct prolongation. We, ourselves, were so fortunate as to discover the structure of the second, or *non-invaginated* type of nematocyst peculiar to the Ctenophoræ (see H. J. C., in Agassiz, Contrib. Nat. Hist. U. S., vol. iii, p. 237, *figs.*). The original sketch of the third kind of cyst, the *colletocyst*, was published by us several years ago in the paper on the "*Cœnotype of Acalephæ*" (Proc. Boston Soc. Nat. Hist., March, 1862; and American Journal of Science, May, 1863).

In previous paragraphs (¶ 110, 208 (A), 117, 115, 212) of this memoir we have described the position of these bodies among the cells with which they are associated, on the colletocystophores, digituli, and the adhesive "disk" of the peduncle. Such is the simplicity of a colletocyst that we can scarcely add anything that will characterize it better than as a "peculiar, granuliferous vesicle," briefly mentioned in the original article above alluded to. Our figures, above enumerated, may assist considerably in forming a conception of its nature. It consists of two kinds of materials, of which one is a perfectly homogeneous, transparent, highly adhesive, and tractile semifluid mass (*figs.* 97, 102, a^2), which prevails to the extreme limits of the cyst, and the other is a coarsely granular, colorless, semitransparent substance (a), which occupies the same area as the first, with the exception of their *peripheral stratum* (a^2). The latter, from its optical appearance, would seem to have the character of a cell-wall, but that is hardly consistent with its office as an adhesive body, nor with its faculty of being drawn out into considerable extensions (*fig.* 102, a^2). It is possible, though, that it is adherent and plastic only on its exposed side; since we may occasionally see two or three colletocysts (*fig.* 96) lying in contact, side by side, and yet with a sharp line of demarcation between them. They vary considerable in size according to locality. Those in the colletocystophores (*figs.* 96, 97, a) have five or six times the diameter of those of the digituli (*fig.* 101, a), and the latter are at least three times the size of those most prevalent in the caudal adhesive disk (*figs.* 118, 120, a).

DESCRIPTION OF THE PLATES I.—XI.; GLOSSARY AND INDEX OF SUBJECTS.

General Lettering of Haliclystus auricula J. Clark.—Throughout the memoir and in the plates corresponding parts are lettered alike, excepting in a few cases where capitals are used to indicate particular regions or subdivisions. For organs and parts, or regions, of organs Greek letters are used, and for minute and microscropic portions, walls, cells, etc., italicized English letters have been adopted.

NUMBER		PARAGRAPH
1.	Anchor (Colletocystophore),*[1] α	13, 104
	" stem, α^1	105
	" nematocystophore, α^2	106, 166, etc.
	" colletocystophoric pad, α^3	106, 166, etc.
	" cavity, α^4	108
	" clear space, α^5	106
	" median furrow, α^6	106
	" shaft of nematocystophore (α^2) α^7	106, 166
	" entrance to, α^8	108
2.	Aboral face of body, β	45
	" projection at base of anchors, β^1	104
3.	Adherent (caudal) disk, γ	114
	" " " furrows, γ^1	115
4.	Caudal disk (see 3)	114
5.	Circumoral area, ζ	43
	" buttresses, ζ^1	39
	" pouches, or their covering, ζ^2	40
6.	Colletocyst, a (κολλητής, *one who glues;* κυστις, *a bladder*)	107, 208 (A), 218
	" pit of, a^1	208 (A)
	" clear peripheral part, a^2	218
6[a].	Colletocystophore (see anchor) (*colletocyst,* φορά, *bearing*)	13, 104
7.	Chondromyoplax in umbel, b (χονδρος, *cartilage;* μυς, *muscle;* πλάξ, *a layer*)	65, 66, 196
	" " tentacle, b^1	100
	" " anchor, b^2	112
	" " genitalia, b^3	137
	" " digituli, b^4	120
	" " intertentacular lobes, b^5	103
	" fibrils of, b^6	196
	" in proboscis, b^7	66
	" " partitions, b^8	67
8.	Chondrophys in umbel, c (χονδρος, *cartilage;* φυω, *to be by nature*)	69, 197
	" " peduncle, c^1	58, 70, 198
	" fibrils, c^2	197, 198
	" in adherent disk, c^3	198
	" innermost layer, c^4	197 (A)

NUMBER		PARAGRAPH
	Chondrophys outermost layer, c^5	197 (A)
9.	Cell-wall (or cell), *d*	193, etc.
	" nucleus, d^1	193
	" contents, d^2	193
	" pigment, d^4	193
10.	Cytoblastema, *e* (κὺτος, *a cell;* βλαστήμων, *producing*)	129
	" tactile bodies of, e^1	203 (A)
	" pigment matter in, e^2 and e^3	206 (B), etc.
11.	Digituli, η (*digitulus, a little finger*)	52, 116
12.	Eye-spot, θ	127
13.	Ectophragma in umbel, *f* (εκτὸς, *outer;* φράγμα, *a wall*)	63, 194
	" " peduncle, f^1	63, 194
	" " adherent disk, f^2	63, 114, 212
14.	Egg, *g*	140
	" yelk-sac, *vs*	141
	" " *vi*	141
	" germinal vesicle, *gv*	142
	" " dot, *wv*	142
15.	Genitalia, λ	50
	" $λ^1$ next longest, $λ^2$ shortest, $λ^3$ longest side of genital half	50
	" distal end, $λ^4$	50
	" proximal end, $λ^5$	50
15ª.	Genital sac, *s*	51, 135
	" " cavity, s^1	135
	" " follicles or pouches, s^2	137
	" " mouth or entrance, s^6	135
16.	Gastromyoplax in digituli, *h* (γαστὴρ, *stomach;* μυς, *muscle;* πλὰξ, *a layer*)	74, 119
	" " genital sacs (see number 24)	74, 85, 137
17.	Gastrophragma in umbel, *i* (γαστὴρ, *stomach;* φραγμα, *a wall*)	75
	" " genital sac (surface), i^1	136
	" within genital sac, i^4	136
	" in tentacles, i^2	76, 101
	" " intertacular lobes, i^3	103
	" " anchors, i^4	76, 113
	" " peduncle, i^5	76
	" " digituli, i^6	118
	" " proboscis, i^7	76
18.	Intertentacular lobes, κ	103
19.	Muscles, *k;* circumoral (see number 22); peduncular (see number 30); of genital sac (see number 24)	103
	" between edges of *b* and *c*, k^1, k^4	82
20.	Nematocystophore (see number 28 and 1) (*nematocyst;* φορα, *bearing*)	82
21.	Nematocyst, *l* (large) (νημα, *a thread;* κυστις, *a cyst*)	94, 203, 216
	" l^1 (small)	217
	" cell-wall, or cavity, *cl*	216
	" cell-mouth, *ml*	216
	" shaft when in, *sl*	216
	" " out (basal half), *bl*	216
	" " " (distal half), *dl*	216
	" thread, *tl*	216
	" thread coiled, *lc*	216
22.	Opsomyoplax in umbel, *m* (οψις, *the face;* μυς, *muscle;* πλὰξ, *layer*)	64, 80
	" at margin, m^1	84

NUMBER		PARAGRAPH
	Opsomyoplax in tentacles, m^2	86, 98
	" band in circumoral face, m^1	83
	" in anchor, m^3	87, 111
	" " partitions, m^4	83
	" " peduncle of anchor, m^5	88
	" " in proboscis, m^6	79
23.	Opsophragma in umbel, n (οψις, *the face*; φραγμα, *wall*)	61
	" " tentacle, n^1	62, 97
	" " anchor, n^2	62, 110
	" " proboscis, n^3	62
24.	Oömyoplax (ὠὸν, *an egg*; μυς, *muscle*; πλάξ, *a layer*)	74, 85, 137
25.	Proboscis, ρ	37
	" mouth, ρ^1	38
	" (buccal) cavity, ρ^2	38
	" base, ρ^3	39
	" buttresses (see circumoral buttresses)	39
26.	Peduncle, τ	54
	" sheath, τ^1	55
	" junction with umbel, τ^2	55
	" canals (cameræ), τ^3	54, 57
	" " entrance to, τ^4	54, 57
	" " anastomoses, τ^5	72
	" furrows, τ^6	115
	" muscles (see 30)	59, 87, 115
27.	Spermatozoa, p	145
28.	Tentacles, ϕ	89, 202
	" shaft, ϕ^1	114
	" spheroidal tip (nematocystophore), ϕ^2	95, 203
	" cavity, ϕ^3	102
	" neck at base of, ϕ^2, ϕ^4	97
29.	Umbella, ψ	41
	" cavity (cameræ), ψ^1	47
	" partitions, ψ^2; proximal end, ψ^5	43
	" margin, ψ^3	82, 84
	" angles, ψ^4	41
	" post-buccal cavity, ψ^6	38, 53
	" passage-ways between cameræ, ψ^7	47
30.	Uromyoplax, r (ουρα, *a tail*; μυς, *muscle*; πλαξ, *layer*)*2	59, 87, 115
	" extension along caudal disk, r^1	88
	" along (ψ^6) post-buccal cavity, r^2	59
	" fibres of, r^3	199
31.	Vibratile cilia, *co*	77, 201

*1 In fig. 25, a^3 should be a^5; in fig. 26, a^1 should be a^7; in fig. 27, a^3 should be a^8.

*2 In figs. 47*a*, 49, and 50, the engraver has erroneously used y and y^1, instead of r and r^1.

PLATE I. *Figures* 1 to 17.

Figures 1 to 16, *Haliclystus auricula* Jas. Clark; natural size and various attitudes and ages. *Fig.* 1, profile view, the umbella turned backward. *Figs.* 2 and 3, anterior face, the arms in two attitudes. *Figs.* 4 and 5, two profile views with the umbella thrown forward. *Fig.* 6, the umbella folded across the middle, and two opposite halves brought near together, face to face. *Fig.* 7, the umbella thrown forward and so contracted at the periphery as to form a deep funnel. *Figs.* 8 to 12, half-grown individuals in various attitudes. *Fig.* 13, a specimen clinging by its anchors to a leaf of Zostera. *Figs.* 14 and 15, the umbella strongly enrolled at the margin. *Fig.* 16, profile of a very young specimen.

Fig. 17. A magnified profile view of a nearly full-grown individual. To avoid confusion only the four nearest bunches of tentacles (ϕ) are represented. Only the aboral side (β) of the umbella is exposed. The anchors (α) are thrown strongly back over the edge of the umbella. The tentacles (ϕ) on the left are expanded to the fullest extent.

PLATE II. *Figures* 18 to 24.

Fig. 18. Posterior face of the caudal disk, magnified 15 diameters, to show the four main furrows (γ^1) and the network of minor furrows.

Fig. 19. Interior face of caudal disk, the peduncle being cut across just in front of it and removed. Principally to show the passage-ways between the four cameræ (τ^3) and the convergence of the four muscles (r^1) to the axis.

Fig. 20. Oral face of a young specimen $\frac{3}{32}$ of an inch across the umbella, magnified 24 diameters. The proboscis (ρ) being strongly contracted appears disproportionately small, but possesses the advantage of exposing the proximal ends of the partitions (ψ^2) of the umbella, as well as of the genitalia (λ).

Fig. 21. Aboral view of a group of tentacles of *fig.* 20.

Fig. 22. Magnified (5 diam.) oral face of a full grown specimen. Only two bunches of tentacles (ϕ) are represented. On the left, above, the proximal end (ψ^5) of the partition and the attachments of the digituli (τ) are exposed by the retraction of the side of the proboscis near them. At the other three quadrants the circumoral pouches are widely covered by the extended flanks (ζ) of the proboscis. The four double genitalia lie, both above and below, right and left of the vertical plane, a partition (ψ^2) lying in the middle of each pair. The three sides of a triangular genital-half are lettered respectively λ^1, λ^2, λ^3. The anchors (colletocystophores) (α) are in varied positions; mostly turned strongly backward over the umbellar margin (ψ^1), two partly reverted, and one projecting straight out so as to fully expose its anterior face with its median furrow. The tentacles (ϕ) are fully extended.

Fig. 23. Lateral view of an adult anchor (*colletocystophore*) with a part of the umbellar margin (magnified 15 diameters).

Fig. 24. Front of basal region of a *colletocystophore* principally to show depth of median furrow (α^6), and the proportions of the stem (α^1) and the colletocystophoric pad (α^3) (15 diam.).

PLATE III. *Figures* 25 to 37.

Fig. 25. Basal front view (magnified 60 diam.) of the anchor, and a part of the umbellar margin of a specimen about two-thirds grown. The anchor is here shown to be supported on its distal side by a prolongation (β^1) from the aboral side (β) of the umbella. The colletocystophoric pad (α^3) is strongly dotted by colletocysts. The remnant of the tentacle-like stage is quite distinct (α^2, α^5) in the distance.

Fig. 26. Magnified (200 diam.) outline profile of a *colletocyst* (anchor) from a young specimen (*fig.* 28) only $\frac{6}{25}$ of an inch across the umbella.

Fig. 27. Anterior face of *fig.* 26, the tentacular character still strongly marked (α^2, α^5, α^7), and the eye-spot (o) very distinct.

Fig. 28. Young specimen, natural size, from which *figs.* 26, 27 were taken.

Fig. 29. Natural size of a young specimen ($\frac{1}{8}$ of an inch across the umbella), from which *figs.* 30, 31, 32, and 33 were taken.

Fig. 30. Posterior face of a *colletocystophore* (anchor) retarded in growth, probably by an injury on that side of the body. From *fig.* 29. As yet it is strongly tentacular in proportions and nature, although the colletocystophoric pad (α^3) is considerably developed. At m^3 is the margin of the muscular layer, (magnified 175 diam.).

Fig. 31. Profile view of *fig.* 30, showing the front face (α^6) to be still purely tentacular.

Fig. 32. Normal development of an anchor, seen in profile, from *fig.* 29 (mag. 175 diam.). The colletocystophoric pad (α^3) is considerably more advanced than in *figs.* 30, 31.

Fig. 33. One of the oldest tentacles of *fig.* 29 (§ 22), fully expanded to show the proportionate thickness of the walls and the relative size of the globular tip (nematocystophore) (ϕ^2). The neck (ϕ^4) at the base of ϕ^2 is well marked (mag. 175 diam.).

Fig. 34. Young tentacle whose nematocystophore (ϕ^2) is not yet distinct from the shaft (ϕ^1), (mag. 175 diam.).

Fig. 35. Abnormal development of colletocysts (α^3) on a young tentacle (mag. 60 diam.).

Fig. 36. Part of the shaft of a tentacle while contracted into a zigzag (mag. 60 diam.).

Fig. 37. Magnified (5 diam.) longitudinal section of adult along two diverse lines, on nearly opposite sides. The section on the left passes through a group of tentacles (ϕ), a genital half (ζ), and through the proboscis (ρ) near one of its corners, and thence backward along the peduncle, just this side of a canal (τ^3) to its posterior end. The section on the right, passing through a colletocystophore (α), extends along the midline of a partition (ψ^2) and of a flat side of the proboscis (ρ), thence along a muscular cord (r^2) in the post-buccal region, and continues to follow it (r) into the peduncle to its expanded posterior end (r^1). The peduncular canal (τ^4) on this side is seen in the distance, beyond the muscular cord (r). The section on the left exposes the umbellar cavity (ψ^1) as well as the digituli (η) festooned about the post-buccal cavity (ψ^6).

PLATE IV. *Figures* 38 to 51.

Figs. 38, 39, 40. Abnormal conditions of the nematocystophore of tentacles (mag. 60 diam.).

Fig. 41. Normal condition of a fully developed tentacle, showing the depressed end of the nematocystophore (60 diam.).

Fig. 42. Fully extended tentacle of a two-thirds grown individual. It very commonly assumes the curved attitude here represented (60 diam.).

Fig. 43. End of a young, but fully formed tentacle, principally to display its ribbed appearance, and the bristling tactile bodies and the nematocysts which dot the globular tip (ϕ^2) (175 diam.).

Fig. 44. Different view of same as *fig.* 43, showing the end of the nematocystophore (ϕ^2), but the shaft curved around into profile, and drawn to exhibit the zigzag position of the innermost wall (ι^2), moving *apparently* free within the outer wall. The great plasticity and extensibility of the intervening layer (chondromyoplax) (b^1) allows these two walls to slide over each other to a great extent, and apparently, with a low power, as if without any intervening connective tissue (175 diam.).

Fig. 45. (20 diam.). Interior of the region about a colletocystophore to expose its entrance (α^8). The oral side (ζ) of the umbella is thrown upward. The margin of the pigment coloring of the aboral side (β) is well marked along the edge of the marginal muscle (m^1).

Fig. 46 (60 diam.). Profile of the posterior end of a peduncular muscle (r) and its extension (r^1) toward the middle of the adherent disk (γ).

Fig. 47 (60 diam.). Section of a colletocystophore and the adjoining umbellar margin, including a portion of the distal end of a partition next an intercameral passage-way (ψ^7), showing the relative thickness and position of the layers, and exposing the interior cavity.

Fig. 47ᵃ (60 diam.). Continuation of the section above figured (*fig.* 47) into the region about the base (ρ^3) of the proboscis; principally to show the relation of the layers of the umbella and the proboscis and to expose the peduncular muscle (γ), where it passes forward into the proximal end (ψ^5) of the partition, and thence diverges into the proboscis (at m^6) and into the umbella (at m^4).

Fig. 48 (350 diam.). A young tentacle contracted; displaying, in a sectional view, the relative position, thickness, and the elementary structure of the layers, and the imbedded nematocysts (l).

Fig. 49 (60 diam.). Interior view of the peduncular muscle (γ) at the point where it plunges forward, narrows (γ^2) a little, and then expands into a flattened layer (m) in the circumoral area. (Compare this with *fig.* 47ᵃ.)

Fig. 50 (60 diam.). Sectional view of the region about the base of the proboscis (ρ), including the post-buccal cavity (ψ^6) and a part of the peduncle. The muscles (r), right and left, are exposed, and the canals (τ^7) lie in the distance, as well as one of the muscles (at r^2) in the post-buccal cavity. In the umbella, m is the expanded prolongation of r^2 each side of the partition (ψ^2). Compare ψ^5 with the same in *fig.* 47ᵃ.

Fig. 51 (60 diam.). Longitudinal section through two diagonally opposite tubes (τ^3) at the posterior end of the peduncle, showing the irregular passage-ways (τ^5) in the region of the adherent disk.

PLATE V. *Figures* 52 to 60.

Fig. 52 (75 diam.). Transverse section of the peduncle to display the relative positions of the muscular cords (r) and the tubes (τ^7), as well as the arrangement of the fibrils of the chondrophys (c^1, c^4).

Fig. 52ᵃ (75 diam.). One of the muscles of the peduncle cut across, and lettered in reference to the main subdivisions.

Fig. 53 (175 diam.). Longitudinal section of one side of the proboscis of a young specimen (*fig.* 84), with a portion of the circumoral area. At ρ^1 to ρ^3 is a face view of the innermost wall (i^7) in the distance.

Fig. 54 (100 diam.). Section, slightly varying in direction, through a group of tentacles, cutting some (A, D) lengthwise, and opening the base of others (B, C), as well as exposing the interior of some of the solid intertentacular lobes (π). The mouth (s^6) of the genital sac (s) is always turned toward the proboscis, as drawn here.

Fig. 55 (100 diam.). Outline view of the globular tip of a tentacle to show the terminal depression.

Fig. 56 (100 diam.). Interior face-view of the region occupied by the intertentacular lobes (π) and the entrances (ϕ^3) of the tentacular cavities.

Fig. 57 (470 diam.). The tissue and pigment granules about the entrance (ϕ^7) to the hollow of a tentacle.

Fig. 58 (175 diam.). Longitudinal section of the basal part of the tentacles, tentacular lobes, and a part of the umbella. The circumoral floor (ζ) thrown up slightly so as to expose the inner face, and the marginal muscle (m^1). From a very young animal (§ 22).

Fig. 59 (175 diam.). A budding tentacle (from *fig.* 58) with a part of the walls of a larger tentacle (ϕ).

Fig. 60 (300 diam.). Sectional view of the base of a tentacle, intertentacular lobe, and the adjoining aboral umbellar margin.

PLATE VI. *Figures* 61 to 66.

Fig. 61 (100 diam.). Section across two extended corners of the umbella and the partition (ψ^2) lying between them. The section across one of the corners is partially omitted, as it is an exact duplicate of the other, reversed. The genital sacs (s) all open (s^6), in one direction, into the umbellar camera (ψ^1). At b^8 the chondromyoplax meets the chondrophys (c^4) and breaks the continuity of the innermost wall (i) of the cameræ, and forms the bulk of the partition.

Fig. 62 (100 diam.). Section across one corner of the umbella nearer its margin than in the last, principally to show the considerable depth of the ridges (m^1, m^1) of the muscular layer, and the peculiar concavo-convex surface of contact of the circumoral (ζ) and aboral (β) floors of the umbella, against the intervening muscular layer (k^1).

Fig. 63 (200 diam.). Section across an umbellar partition (ψ^2) and a part of the circumoral and aboral floors near it, at a point nearer the proboscis than in *figs.* 61 and 62, including one of the youngest genital sacs (s).

Fig. 64 (200 diam.). Longitudinal section at the same point as *fig.* 63, cutting the partition (m^4) lengthwise.

Fig. 65 (200 diam.). A group of digitiform bodies (digituli) pendent from the circumoral floor. One of them is remarkable for its triple forking.

Fig. 66 (5 diam.). The peduncle and a part of the umbella near a partition (ψ^2), including a marginal body (colletocystophore) (a); chiefly to display the distinctness, from an exterior view, of the canals (τ^3), and the filmy caudal sheath (τ^1). The deep furrow (τ^6) lies over the muscular cord which extends forward into the partition (ψ^2, ψ^5) of the umbella.

PLATE VII. *Figures* 67 to 84.

Figs. 67 to 73 (175 diam.). A progressive series of developments of the genital sac, seen from different points of view. *Fig.* 67. View from within the umbella. *Fig.* 68, same as *fig.* 67, but seen from the end opposite the entrance (s^6) of the sac, the outer wall (i) overlying the initiatory double folds (i^1) of the inner, or ovigerous layer. (Compare *fig.* 74, and adult sac.) *Figs.* 69 and 70, face and profile of the same sac seen from within the umbella. *Figs.* 71 and 72 face and end views of the same sac, the third in the series, seen from the exterior, through the circumoral floor. *Fig.* 73, the fourth and last of the series, seen from without, as in the last.

Fig. 74 (350 diam.). One of the smaller genital sacs, of an adult female, sectional profile, pendent from the circumoral floor. The aperture (s^8), surrounded by large vibratile cilia, leads into a central chamber (s^1) surrounded by ovigerous follicles.

Fig. 75 (350 diam.). View from opposite the entrance (s^8) of a male genital sac. The follicles (s^2) converge toward and open into the central chamber (s^1).

Fig. 76 (350 diam.). The same as *fig.* 75, seen through the circumoral floor, from a different point of view.

Fig. 77 (350 diam.). Empty female genital sac, chiefly to show the manner in which the follicles (s^2) open into the central chamber (s^1).

Fig. 78 (350 diam.). An egg-follicle to illustrate the histological character of the ovigerous layer (i^1) (internal oöphragma), and the position of the eggs (vi).

Fig. 79 (350 diam.). An empty egg-follicle dotted all over with the torn fragments of the fibrils of the chondromyoplax (see *fig.* 77, b^3).

Fig. 80 (200 diam.). Singular attitude of a digitulus (η), its sides folded together to form a sac with a broad mouth (ηs), imitating a genital sac (s^1).

Fig. 81. An anchor (colletocystophore) of a very young individual (*fig.* 84 nat. size), and a portion of the umbellar margin. The edge of the muscular layer (opsomyoplax) (k^4) is seen passing obliquely from the front to the distal side. (See the dotted line k^1, k^4, in *figs.* 82 and 83.)

Fig. 82 (175 diam.). A combined outline and sectional view from the distal side of a young anchor (from *fig.* 84). The nematocystophore (a^2) in the distance. The dotted line (k^4) indicates the course of the edge of the opsomyoplax (k^4) as it crosses the distal side of the base of this organ. The distal end of a partition (ψ^7) is seen through the thick mass of the aboral side of the umbella. The arrow lies in the intercameral passage-way. (See ψ^7, *fig.* 83.)

Fig. 83. Profile section of the same as *fig.* 82, with a part of the umbella. The dotted line (k^4) is the same as in *fig.* 82, continued onward to the circumoral floor, where it becomes a part of the true umbellar opsomyoplax (m^4). In the anchor it is marked m^2.

PLATE VIII. *Figures* 85 to 93.

Fig. 85 (750 diam.). Portion of the opsophragma (n) and the underlying opsomyoplax (m) of the circumoral floor, in profile.

Fig. 86. Face-view of the cells of *fig.* 85.

Fig. 87 (750 diam.). Face-view of the cells of the ectophragma of the aboral side of the umbella, remarkable for the accumulation of pigment granules (d') about the nucleus.

Fig. 88 (750 diam.). Profile section of the outer wall of the globose tip (nematocystophore) of a young tentacle, with the imbedded nematocysts (l the larger and l' the smaller).

Fig. 89. End view of the same as *fig.* 88.

Fig. 90 (750 diam.). A combined longitudinal sectional and surface view of a part of the shaft of a tentacle. At n^1 the opsophragma is in profile, and at $1n^1$ it is presented as seen at the surface, extending partly across the field. At $1m^2$ the opsomyoplax is in profile, and at $2m^2$; $3m^2$ are the fibrils of the same, nearer the eye, underlying the opsophragma ($1n^1$) and overlying the chondromyoplax (b^1) and the gastrophragma ($1i^7$) in the distance. Next within the muscular layer lies the chondromyoplax, which is seen partly in sectión (at b^1), and a small portion at the exterior surface (b^1) as it curves over and rises, toward the observer, from the distance. The innermost wall (gastrophragma) is seen, also, partly in profile (i^7) and partly at the surface ($1i^7$), the cells being presented endwise.

Fig. 91. Transverse section of *fig.* 90, representing a little more than a quadrant of the cylinder. At m^2 the muscular fibrils are cut across. The wedge-shaped character of the cells of the gastrophragma (i^7), as they diverge from the central cavity (ϕ^3), is quite evident.

Fig. 92 (750 diam.). Face view of the cells of the outer wall (d) and the underlying muscular fibres (m^2), to show the linear arrangement of the former when the tentacle is contracted.

Fig. 93. Profile of *fig.* 92, to compare with the cells of the same wall (in *fig.* 90, n^1) when the tentacle is extended.

PLATE IX. *Figures* 94 to 108.

Fig. 94 (750 diam.). The innermost wall (gastrophragma) of the anchor of a three-quarters grown animal, exhibiting its enormous thickness at one part (B), and its gradual thinning out (A to D); as well as the great masses of pigment (d^1) in the cells.

Fig. 95. Face-view of the same as *fig.* 94.

Fig. 96 (350 diam.). The outer wall and the imbedded colletocysts (a) of an anchor. At a^1 the pit in which such as a are sunken.

Fig. 97 (750 diam.). More highly magnified views of a part of the same as *fig.* 96; a part of the cells are omitted so as to expose more clearly the structure of the colletocyst (a), particularly its clear periphery (a^2).

Fig. 98 (175 diam.). A combined surface and longitudinal sectional view of a digitulus and a genital sac. At A and B the opposing flat sides are seen edgewise, meeting along the midline of the figure; at A, distinguished by the crowded colletocysts, and at B and C, by the nematocysts. At D is a section of the thickness from face A to face B. The mouth (s^6) of the genital sac is quite wide open.

Fig. 99 (550 diam.). The colletocystic side of a portion of *fig.* 98, partly at the surface ($1a$) and partly so as to expose the underlying muscular fibrillæ (h) and the layer of colletocysts in profile (at a).

Fig. 100. Transverse section of the same as *fig.* 99, displaying on one side the nematocysts (l), and the very long vibratile cilia (co), and on the other the crowded layer of colletocysts (a).

Fig. 101 (750 diam.). More highly magnified view of a part of the adjoining nematocystic (l) and colletocystic (a) faces of the same as *fig.* 98.

Fig. 102 (750 diam.). Colletocysts with the periphery drawn out to various lengths (a^2).

Fig. 103 (350 diam.). A part of *fig.* 99, after treatment with fresh water; the colletocysts adherent after the cells of the wall have fallen away, and exposed the fibrillæ (h) of the gastromyoplax.

Fig. 104 (750 diam.). Some gastrophragmic cells (i) and fusiform fibrils (r^2) of the muscular layer at the point where it passes into the cords of the peduncle.

Fig. 105 (750 diam.). The innermost wall (gastrophragma) (i^5) lining two adjoining, nearly completed, irregular passage-ways between the tubes of the peduncle. Near A, new cells are forming between B and C, pushing their way through the solid mass of chondrophys (c^1), and eventually becoming the face-wall of the passage (τ^1), here in process of excavation.

Fig. 106 (350 diam.). Face-view of the fibro-cellular chondrophys of a very young specimen (*fig.* 82).

Fig. 107. Profile of one of the fibro-cellular elements of *fig.* 106, taken near the thinning edge of the chondrophys (see *figs.* 82, 83).

Fig. 108 (750 diam.). A more highly magnified egg, from *fig.* 74. The mulberry-like character of the yolk (*vi*) is remarkable.

PLATE X. *Figures* 109 to 129.

Fig. 109 (1050 diam.). Profile section of the outer wall (oöphragma) of a genital sac, principally to illustrate the relation of the vibratile cilia (*co*) to the cells of this wall, and the interstitial cytoblastema in which the cilia-bases are imbedded.

Fig. 110 (1050) diam. Surface view of the same as *fig.* 109, the large pigment and colorless granules lying nearest the observer. From an unusually large individual.

Fig. 111 (350 diam.). From the same layer as in *figs.* 109, 110, acted upon by fresh water, which has resolved the elements into separate cells.

Fig. 112 (1050 diam.). E to K. Vibratile cilia from diverse regions of the interior. E is from the surface of the genital sac (*fig.* 109), and the rest from the inner face of the circumoral floor, near the margin of the umbella. They are represented in various attitudes, as they move with the cilium in front of the swollen basal portion.

Fig. 113 (200 diam.). Portion of the proximal face of a peduncular cord, showing the deep furrows ($\frac{1}{2}$, $\frac{1}{3}$) and the intervening ridges ($\frac{1}{4}$).

Fig. 114 (750 diam.). A small portion of *fig.* 113, more highly magnified, showing an apparently clear cellular structure, with large homogeneous interspaces. Its true nature is seen in *fig.* 116. The tissue is strongly contracted.

Fig. 115 (750 diam.). Some loosened cells from *fig.* 114.

Fig. 116 (750 diam.). Showing the fibrillæ (r^3, $1r^3$, $2r^3$) and cells of the peduncular cords; from the same individual as *fig.* 114, but in a highly extended condition, just after death has ensued.

Fig. 117 (470 diam.). Transverse section of one of the main subdivisions of a muscular cord of the peduncle, next the median furrow ($\frac{1}{3}$) of *fig.* 113, showing the deep minor furrows.

Fig. 118 (750 diam.). Profile section of the outer wall of the adherent disk of the peduncle, with its imbedded adherent vesicles (*a*).

Fig. 119 (750 diam.). Inner face-view of the same as *fig.* 118, displaying only the cells (f^1) and the nematocysts (*l*) in the distance.

Fig. 120 (750 diam.). Outer surface view of the same as *figs.* 118, 119, showing only the crowded colletocysts (*a*) and the very minute nematocysts (*l*).

Fig. 121 (24 diam.). Front view of a very young individual ($\frac{1}{18}$ of an inch across the umbella alone). The different groups of tentacles vary considerably in the number of their components. The numbers 1, 2, 2^a, 3, 3^a, etc., refer to tentacles of successively younger development; and the capital letters A, A^1, B, B^1, C, C^1, refer to the groups which have respectively, four, or five, or six tentacles. The tentacular nature of the colletocystophore (a) is quite marked, as yet.

Fig. 122 (45 diam.). A, B, C, D. Variously developed groups of tentacles and an anchor from *fig.* 121. Group A, of four tentacles seen endwise. Group B, of five tentacles seen in front. Group C, of six tentacles also seen in front. No. 1 is the oldest and No. 4^a the youngest tentacle of these groups. They are numbered and lettered to correspond with the same in *fig.* 121. The anchor (D) is seen in profile, fully extended.

Fig. 123 (85 diam.). An anchor, the same as *fig.* 122, D, slightly contracted. A surface view, showing the interior in the distance.

Fig. 124. Natural size of a very young animal.

Fig. 125 (40 diam.). View of the aboral or distal side of a group of tentacles from *fig.* 124. The numbers 1 to 6^a refer to successively younger tentacles.

Fig. 126. Front view of the same as *fig.* 125, less magnified.

Fig. 127 (175 diam.). Basal view of part of the adherent disk of the peduncle, of a very young individual (*fig.* 124). Remarkable for the abrupt termination of the muscular cord (*r*) and the disconnected tubes (r^1).

Fig. 128 (175 diam.). Portion of a transverse section of the peduncle of *fig.* 124, at a point half-way between its two ends. Remarkable for the horse-shoe form of the section of the hollow muscle (*r*), as in the last figure (*fig.* 127, *r*).

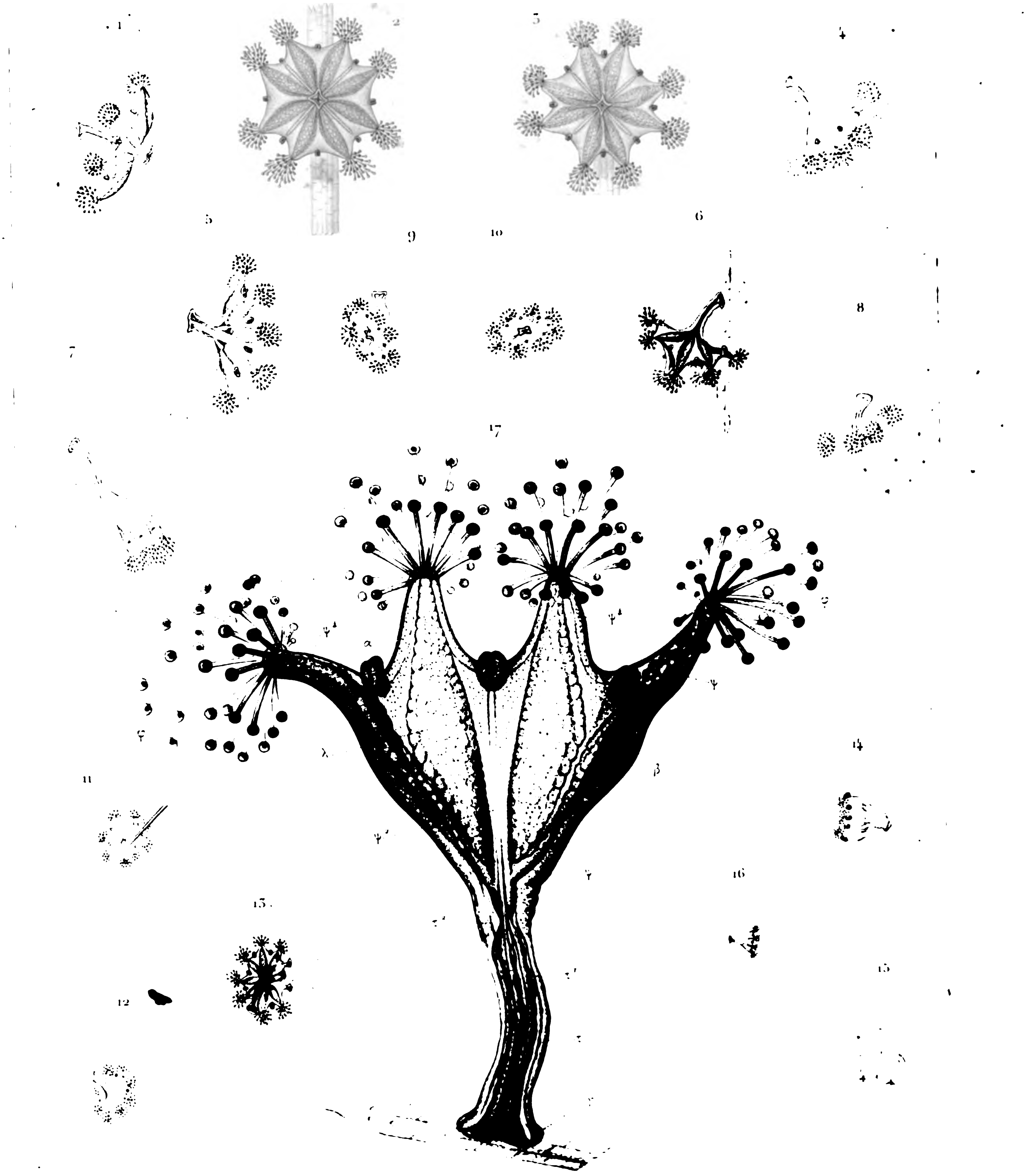
Fig. 129 (350 diam.). Portion of a space between two adjoining peduncular tubes (*fig.* 128), showing the irregular form and granulation of the young fibrillæ (c^2) in the homogeneous cytoblastema of the chondrophys.

PLATE XI. *Figures* 130 to 145.

Figs. 130, 131, 132 (1050 diam.). Spermatic particles at the moment of escape from the genital sac.

Figs. 133 to 141. Larger kind of nematocysts from the tentacles, in various degrees of eversion, or at rest. *Figs.* 138 and 141, of diagramatic size, and the rest, from *fig.* 133 to 140, magnified 1050 diameters. *Fig.* 133. Not fully grown nematocyst, closed. A part of the coil omitted to expose the central shaft (*sl*). *Fig.* 134. Fully developed cyst, but not the largest, closed. A sectional view, the coil in the distance (*lc*). *Fig.* 135. The basal half of the shaft (*bl*) everted. *Fig.* 136. The whole shaft (*bl, dl*) everted. *Fig.* 137. The whole shaft (*bl, dl*) and a part (A) of the hollow thread everted. *Fig.* 138. Partly everted thread, showing the manner of its sliding within itself. *Fig.* 139. A completely everted cyst, showing the spiral rows of bristles on the shaft and the twisted triangular thread (*tl*). At D, the blunt tip of the thread. *Fig.* 140. The end of a shaft rapidly tapering into the thread after eversion. *Fig.* 141. Diagramatic view of the base of the thread, showing the spiral course of the edges of the twisted trihedral, and the abrupt termination of the rows of setæ of the shaft.

Figs. 142 to 145. The smaller nematocysts, from the tentacles (1050 diam.). *Fig.* 142. Fully developed cyst, closed. The coil partly omitted, not to confuse the connection of the shaft (*sl*) with the thread. *Fig.* 143. View from the side opposite to the one seen in *fig.* 142, showing the termination (*lc*) of the thread, and its mode of coiling. *Fig.* 144. View at ninety degrees from that of *fig.* 143. *Fig.* 145. The thread totally everted.



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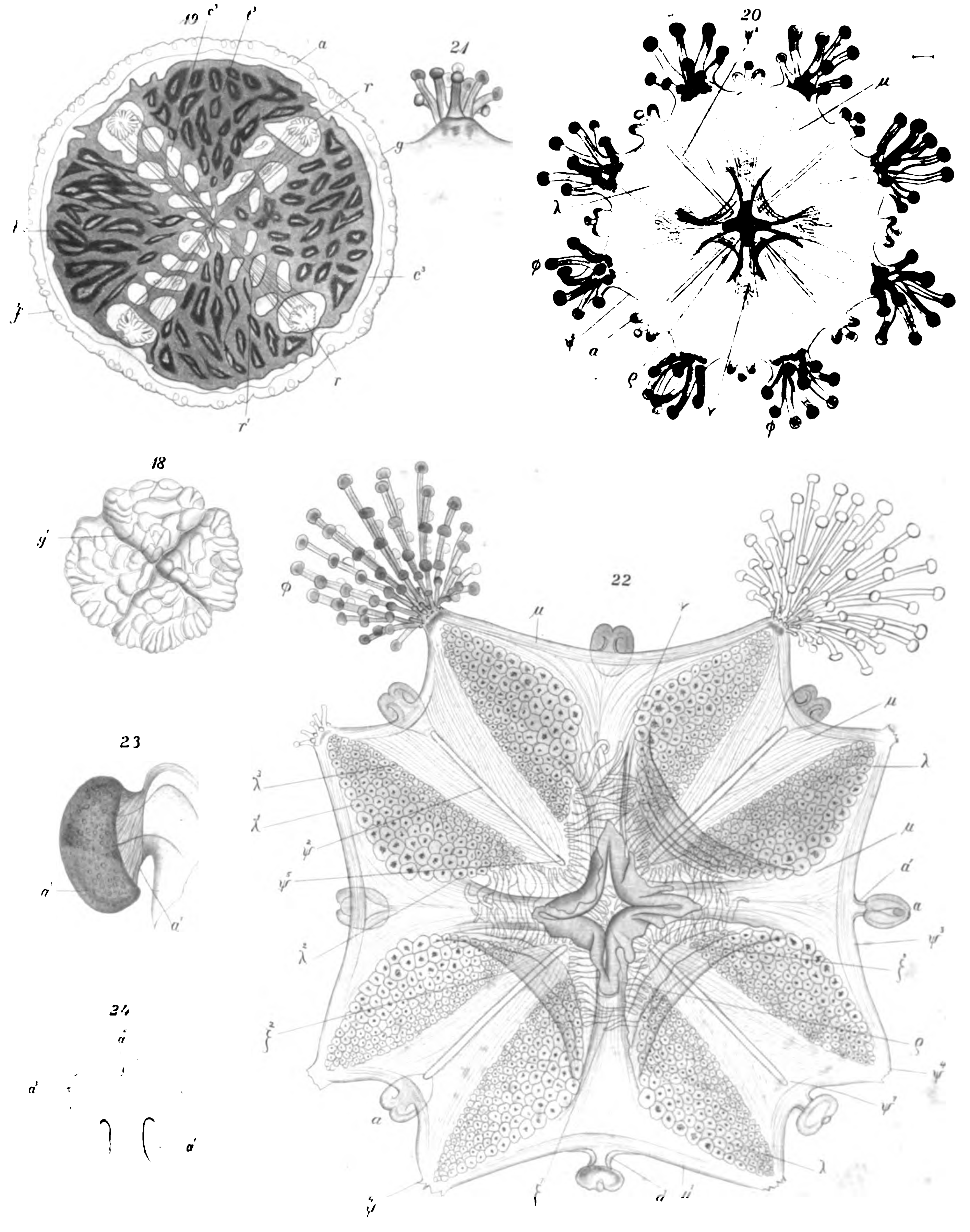
Haliclystus auricula. Jas. Cl. (Fig. 1-17)



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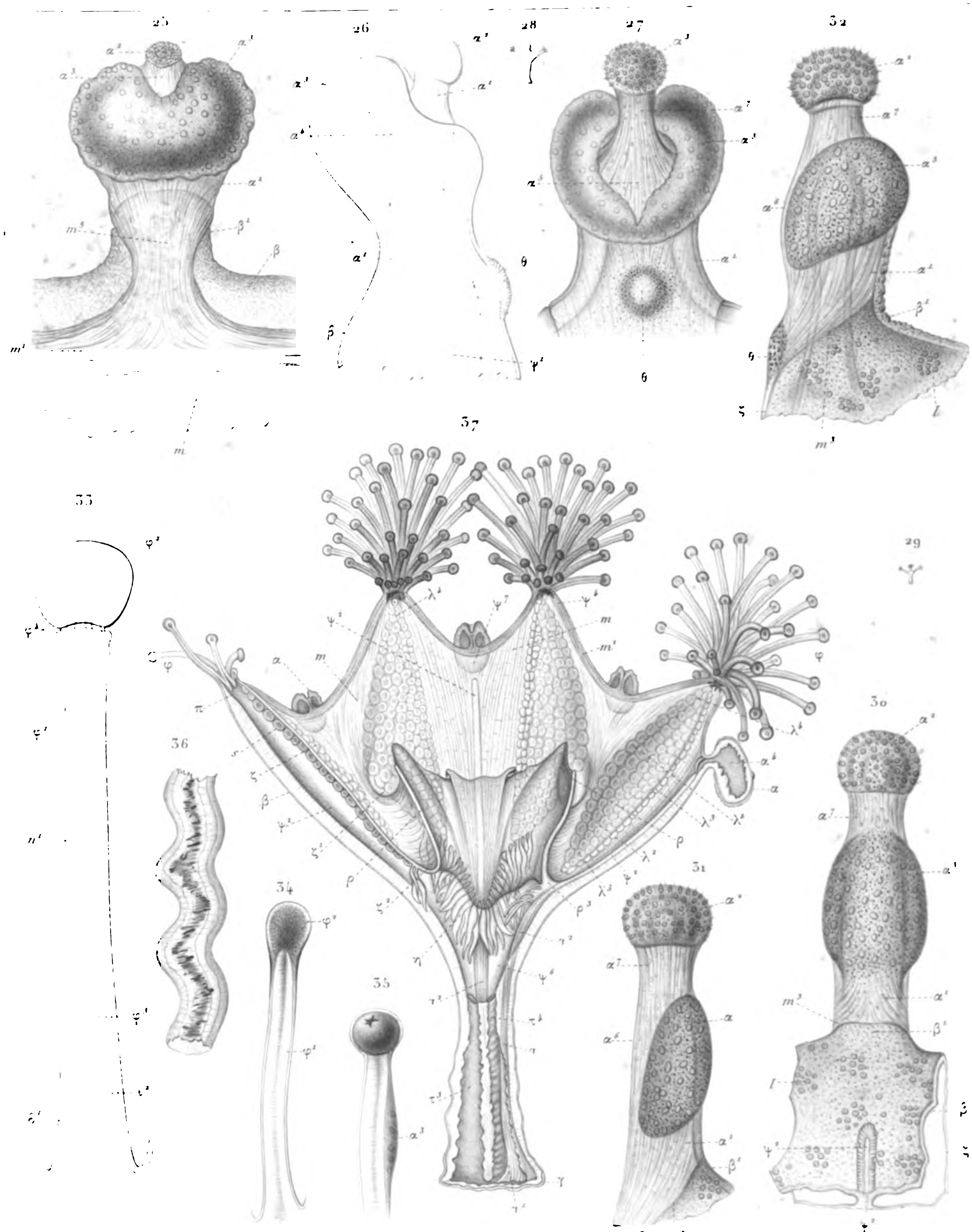
Haliclystus auricula Jas. Cl. (Fig. 18-24)



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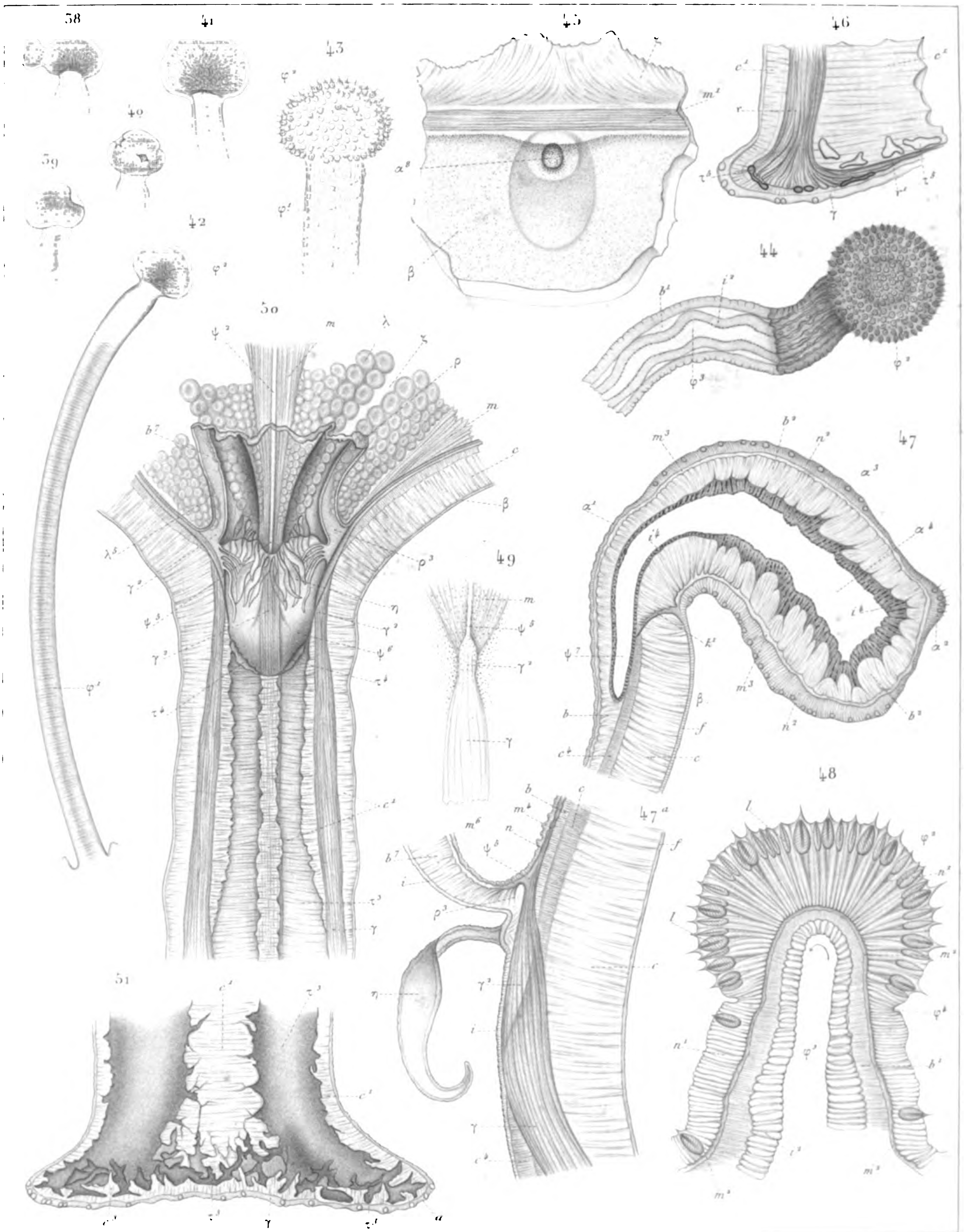
Haliclytus auricula. Var. (?) (Fig. 25-37)



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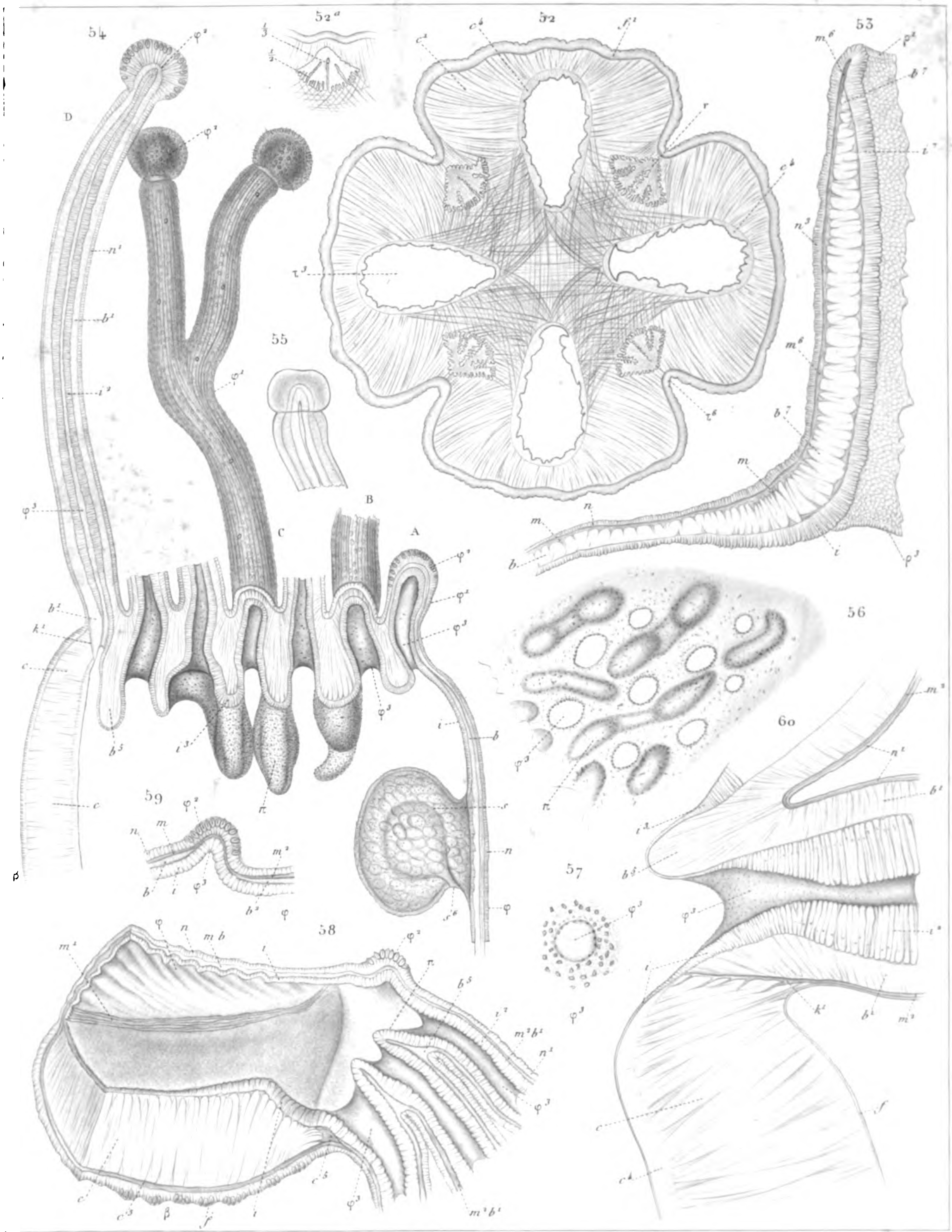
Haliclystus auricula Jas. Cl. Fig. 38–51.



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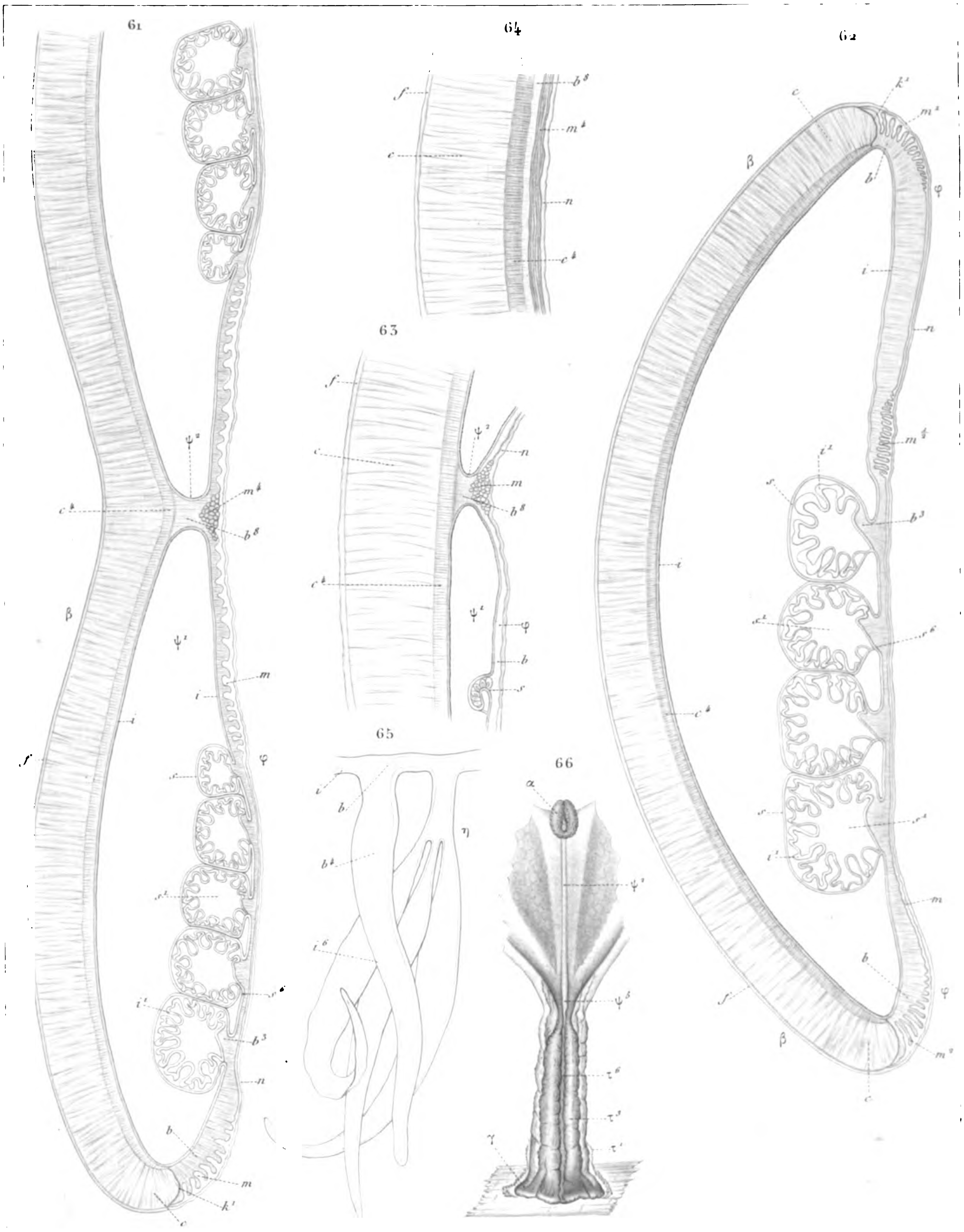

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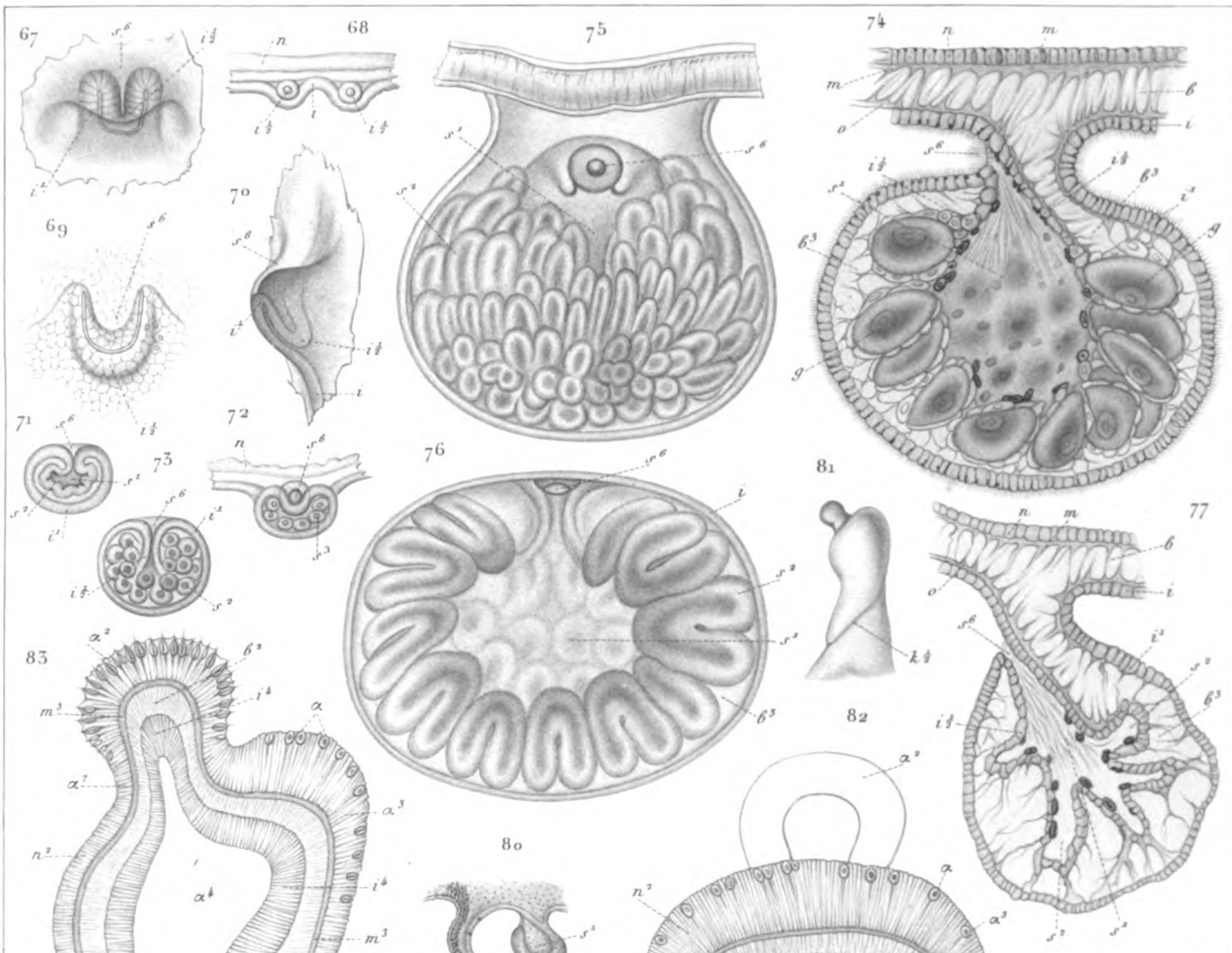
Haliclystus auricula, Jas. Cl. (61-66.)



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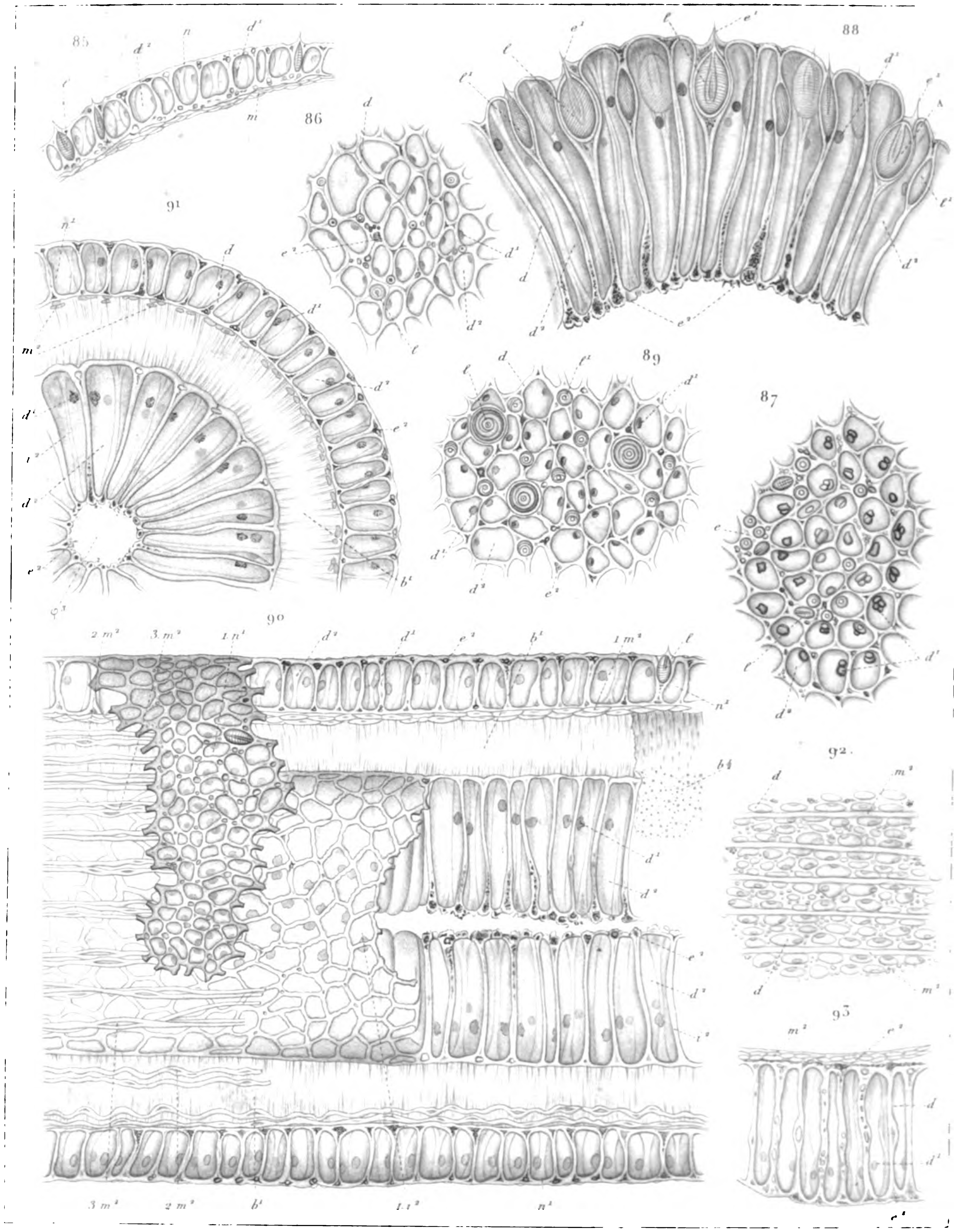
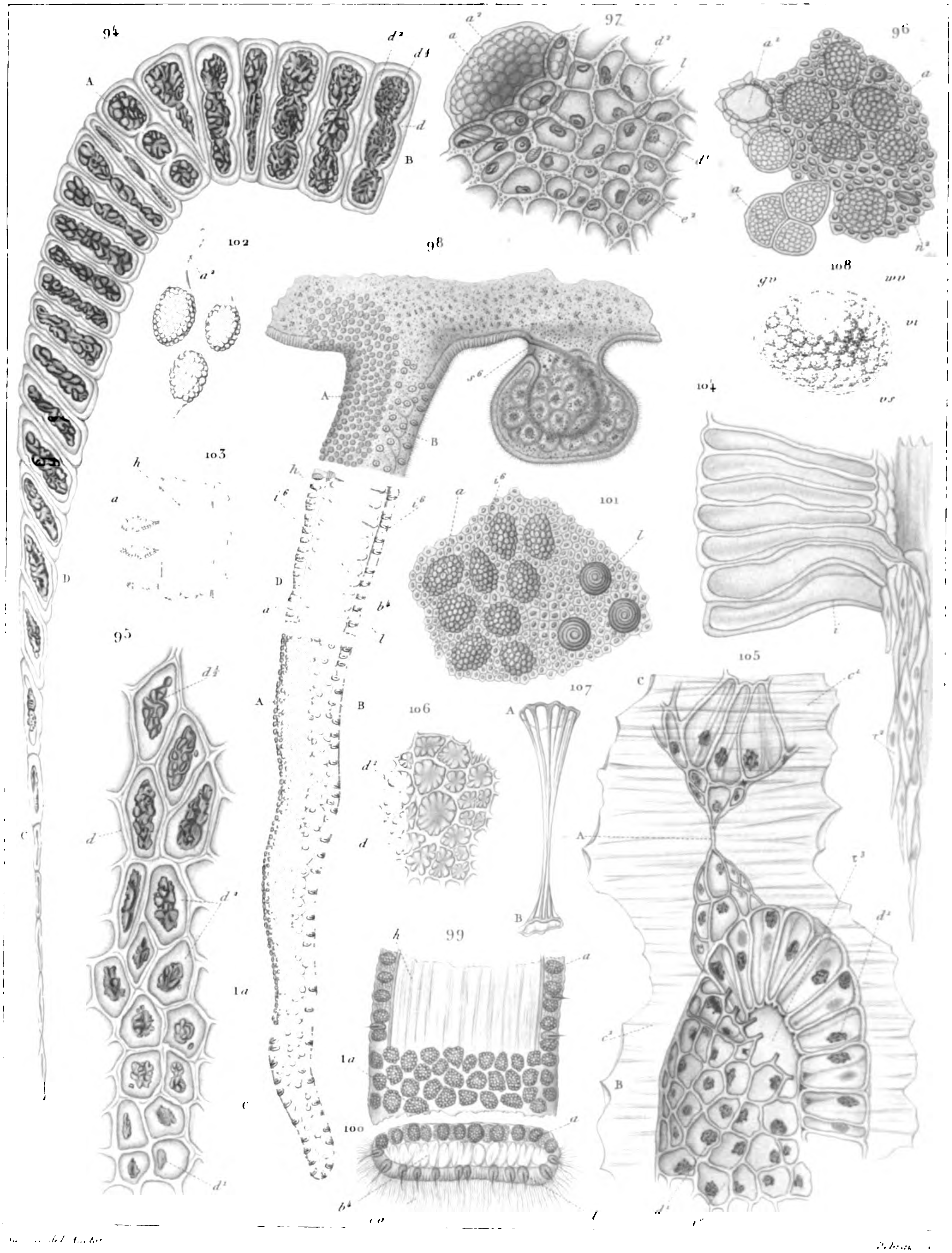
Haliclystus auricula. Jas. Cl. (Fig. 67-84.)



Haliclystus auricula. Jas Cl. (Fig. 85-93)



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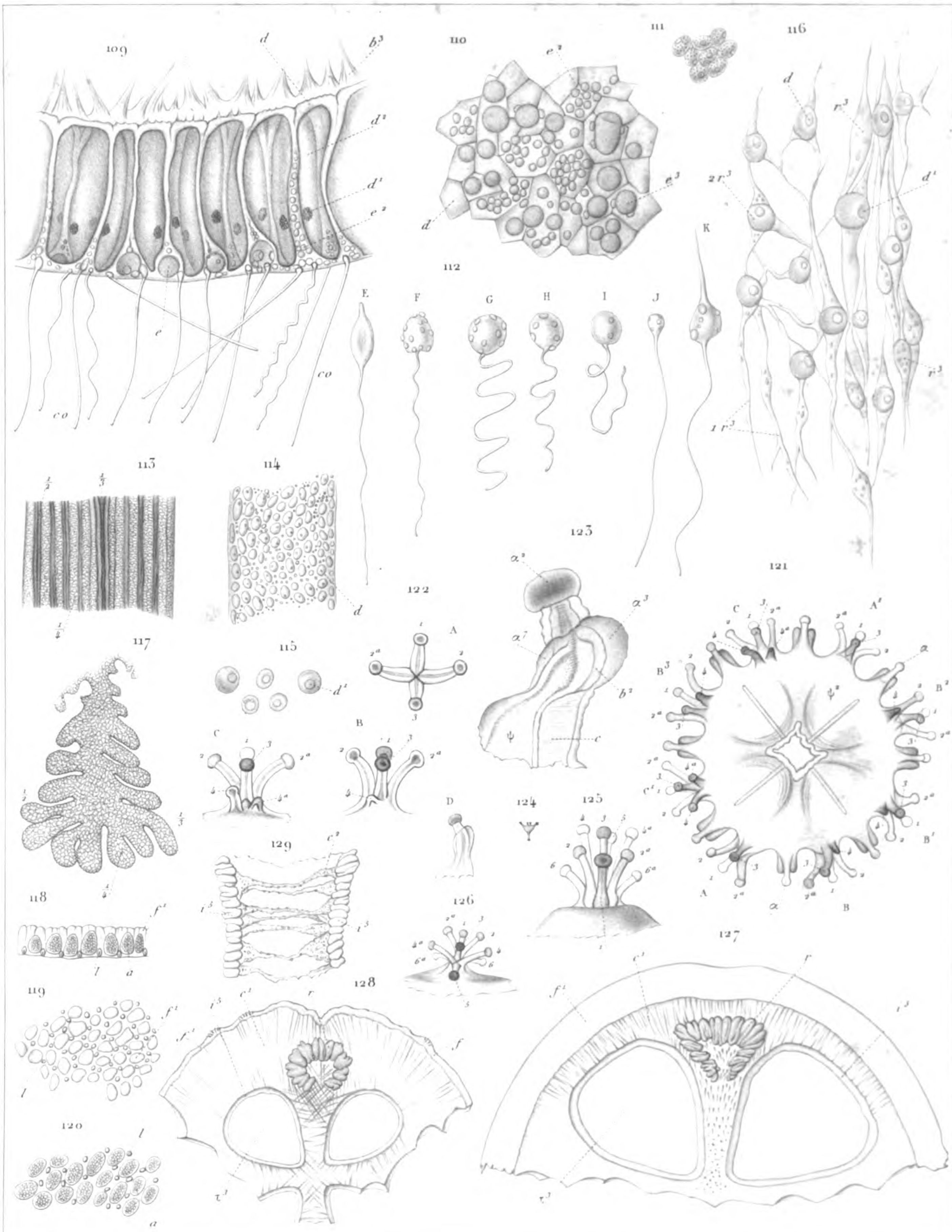

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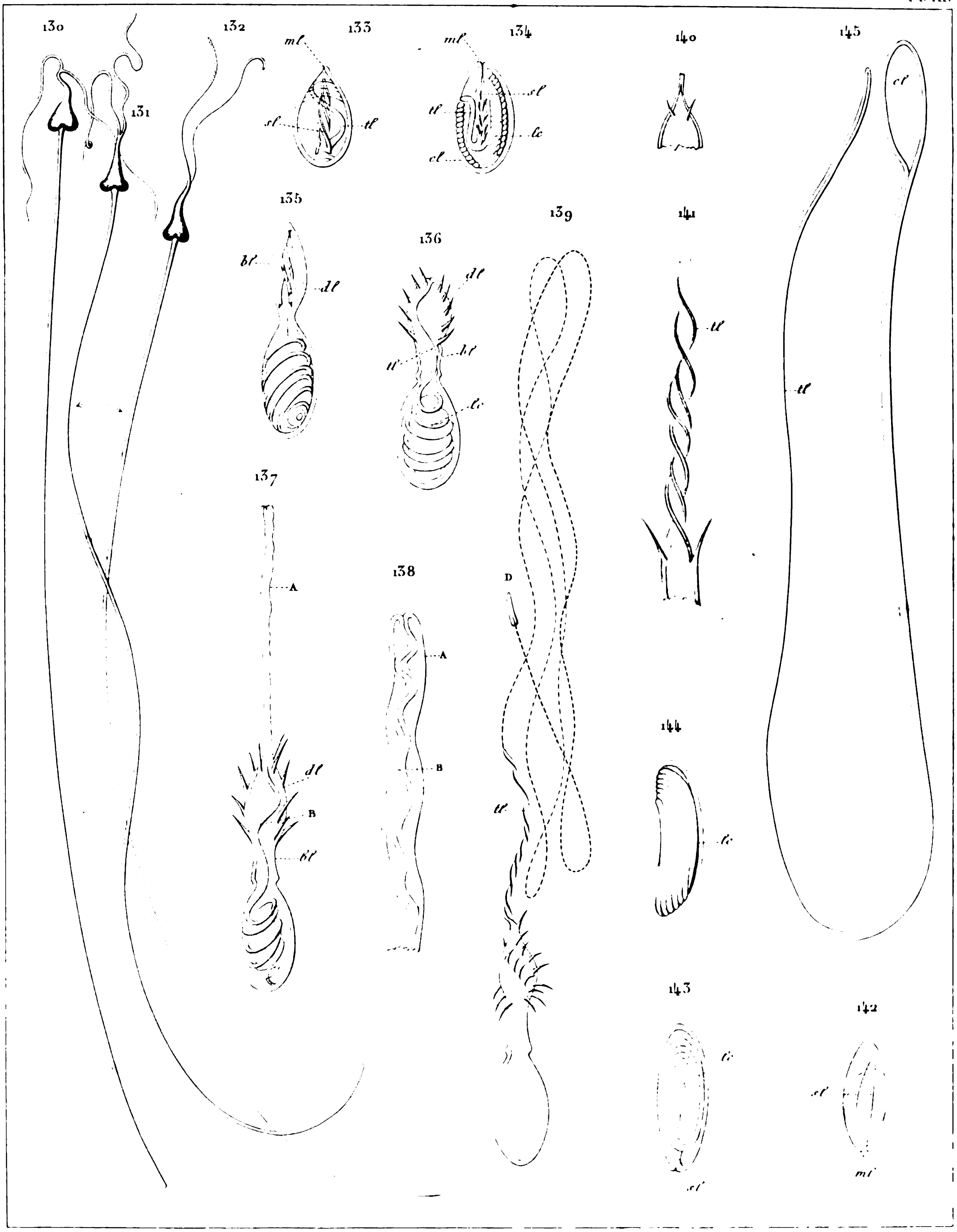
Haliclystus auricula. Jas. Cl. (Fig. 109-129)



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Haliclystus auricula. Jas. Cl. (Fig. 130-145)