IX.

Contributions to the Natural History of the ACALEPHÆ *of North America.*

BY L. AGASSIZ.

PART I. — *On the Naked-eyed Medusæ of the Shores of Massachusetts, in their Perfect State of Development.*

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THERE is a deep scientific interest connected with the study of Medusæ. Notwithstanding their slight consistency and their extraordinary transparency, a highly organized structure has been observed in many of them; and, though the most opposite opinions still prevail among observers respecting the signification of the facts thus ascertained, it is not the less evident that their structure deserves to fix the attention of physiologists in the highest degree. It is, in reality, one of the most wonderful sights which the philosophic naturalist can behold, to see animals scarcely more dense than the water in which they play, and almost as limpid, perform in that medium movements as varied as those of the eagle which soars in the air, or of the butterfly dancing from flower to flower, testifying by their activity their sensitiveness and their volition. Their mode of living, as far as it is known; their periodical appearance, like annual or biennial plants; their rapid growth; the short duration of their life; the brightness or softness of the light which they emit during night, and which illuminates even the deep ocean; the wonderful facts which have been ascertained respecting their mode of reproduction; — all this is of a character to strike, in the highest degree, the curiosity even of the most careless. It is, therefore, not surprising, that, from time immemorial, the phosphorescence of the sea, which is, in a great measure, owing to the presence of jellyfishes, should have excited the deepest interest, and that, of late, the natural history of Medusæ should have become one of the most fascinating subjects for the ablest scientific observers, and opportunities to trace and repeat their researches, a matter of the most ardent desire on the part of inland naturalists, whose curiosity has been excited to the utmost by the narrative of so many wonders.

A new-comer into the field of these researches, after having spent the best of my earlier years in other labors, and happy to find still something to glean where Péron and Lesueur, Cuvier, Eschscholtz, Ehrenberg, Milne-Edwards, Mertens, Brandt, Lesson, Sars, Loren, Steenstrup, Von Siebold, Dujardin, Will, Edward Forbes, Sir John Dalyell, and others, have reaped full harvests, I have not the pretension to offer any thing very complete upon this subject.

Three years of study on the sea-borders have hardly yet fully opened my eyes to its inexhaustible treasures. I bring only some loose fragments respecting several points of the structure of Medusæ, before unknown or little understood, which I have attempted to clear up, as far as it has been in my power.

In the illustration of the objects which I am about to describe, I have been largely assisted by the ability of Mr. Sonrel, whose quickness in seizing the characteristic features of organized beings, and in reproducing them with a delicate touch, I have already had opportunities to appreciate, during the publication of my researches upon the fossil fishes, and those of the fresh waters of Europe, and also upon the Echinodermata and shells. All the illustrations of Medusæ which I now publish are drawn, as well as engraved, by his hand. The part which he has taken in this work is so important, that, I am happy to acknowledge, without his aid, I should have been unable to reproduce, or, at least, to make equally intelligible to others, the facts which I had ascertained.

Some of the numerous figures which I have caused to be engraved may appear rather superfluous. But it must be considered that these animals are so perishable, that it will hardly ever be possible to preserve extensive series of them in our museums, or to procure of those capable of preservation a sufficient number to represent them in their different attitudes and under various circumstances, so as fully to illustrate all the details of their structure. For, though entire specimens of the smaller species may be preserved in Goadby's liquid with tolerable success, yet details which may be traced in the fresh state are almost always lost soon after. Moreover, they have to be traced under rather high magnifying powers, and for some details the highest powers at our command are hardly sufficient for the investigation. It must be obvious, therefore, that full original illustrations of as many of these animals as can be obtained will be always of service to the progress of science, and should at once be secured whenever the opportunity offers of investigating the new forms which fall within our reach; especially when we consider that, in many cases, opportunities may not be afforded for years again to investigate the same subject in the same state.

I should mention, also, some advantages I have derived from availing myself of various methods of proceeding in studying these animals. While many details of structure can be made out only from living or perfectly fresh specimens, there are others which may be best observed in those which have been for some time dead. We should, therefore, be in no hurry to place living Medusæ under the microscope; or to take them out of the water to observe them more closely. We may first watch their movements, and trace, as far as possible, in the complete specimen, the connection of parts, and the influence which the movements have upon the circulation of fluids, and upon the changes of form of the whole body. We may next proceed to the investigation of those external details which are best traced upon fresh specimens, such as the microscopic structure of the tentacles, the fringes of the mouth, the eye-specks, by cutting such parts from living specimens, which will survive for some time after this operation. But we should carefully preserve the dying and dead bodies, and closely watch the process of decomposition; for, during the cadaveric stiffening of the animal, tissues may be discovered which remain unnoticed in the living or fresh animal. Such is particularly the case with the muscular, or rather contractile, system of cells by which the voluntary movements are effected, and which are best seen when strongly contracted. Of course, the forms exhibited in the contracted state are neither natural nor frequently observed during life, as they only exemplify the action of the contractile tissue in its utmost state of contraction. But if we do not obtain in that way a satisfactory view of the object, we, at least, learn where to look in order to study these parts in a more natural condition, and gradually to discern them where their existence was unsuspected before. Even fragments in a decayed state should not be neglected, as the manner in which the parts separate during decomposition affords the means of ascertaining the limits of the different tissues; some decomposing more readily than others, under the same circumstances. For instance, the easiest way to study the epidermis, or simple layer of epithelial cells, which cover the whole surface of the body of Medusæ, is to allow decay to commence without disturbing them; when it will be easy, after a certain time, to take off a thin, continuous layer of the most beautiful polygonal, nucleated cells, forming a single layer over the whole surface.

The most active species, when it is desirable to study them alive, can easily be brought to a state of immobility by ether or chloroform. I have frequently seen even the smallest species, such as Hippocrene, recover from a state of perfect immobility and insensibility to active life again. Even had I not succeeded in finding distinct sensitive apparatus, I should, from this very fact, have been led to claim for them the power of feeling, so plainly shown by such experiments.

Another method of studying these animals, used frequently to great advantage, has been, to drop them into liquids of various densities, — into fresh water, for instance, or into alcohol, or various saline solutions; when the differences of shade introduced in the tissues of different kinds has often proved a useful means of ascertaining structural details otherwise indistinct, or altogether undiscovered. All these different modes of investigation have been repeatedly tried under various circumstances.

I may be allowed to mention, also, that I have used, with great advantage, Goadby's liquid for the preservation of Medusæ, with all the care and precautions indicated by Professor Edward Forbes, in his admirable *Monograph of the British Naked-eyed Medusæ.* It is important that every one who repeats these investigations should be fully assured that his success in preserving good specimens will depend altogether upon the care he takes in using successively the liquids of different density, and also in changing regularly and frequently the liquid in which the specimens are immersed, until they are fairly saturated and the process of endosmosis has ceased to go on. I have lost most valuable specimens from having trusted too soon to the preserving power of the liquid in its first applications.

SARSIA.

In the year 1835, Sars published, under the name of Oceania tubulosa, a description, with figures, of a small Medusa discovered by him on the shores of Norway. It is found in that most remarkable little volume of his "Descriptions,"* which contains the germs of so many important developments in our knowledge of the lower animals. This species was afterwards taken as the type of a new genus by Lesson, who, in his work on Acalephæ,† describes it under the name of Sarsia tubulosa. Since that time, a few species have been added to those mentioned by Lesson.

It would seem as if the genus Sarsia was now fairly established, as it rests upon well-defined and easily ascertained characters; but since it has been discovered that Sarsia is only one condition of development of animals which differ widely at other periods of the year, it now remains for us to ascertain under what generic name it should finally stand in our system. For the common Coryna or Syncoryna represents one of their stages of growth, and the Oceania or Sarsia is another. And it must have been a high satisfaction to Sars, who first discovered the species, and introduced it to the notice of naturalists, to have also been the first to perceive that these little Medusæ are developed from a polyp-like stem, which alternates in their generations with the free Medusæ.‡

* *Beskrivelser af Polypernes*, &c. Bergen, 1835. 4to.

† *Histoire Naturelle des Zoophytes. Acalèphes.* Paris, 1843. 8vo.

‡ *Fauna Littoralis Norvegiæ.* Christiania, 1846. fol.

The existence of this type on the American shores was first mentioned by Dr. Gould, in his Report on the Invertebrate Animals of Massachusetts, in which Oceania tubulosa of Sars is enumerated among the animals occurring along these shores. They were among the earlier Medusæ I saw on this continent, Dr. Gould himself having kindly showed me the localities where he procured them. Since that time, early in the spring of 1847, I have also obtained, by dredging, specimens of the Coryna of Boston Bay, from which the perfect Medusa is derived.

We have here a double question to settle, — first, whether the European species is identical with that of North America, and, next, under what generic name this species should finally stand in our system. This is a matter of no slight importance, now that the zoölogical nomenclature can no longer be viewed in the same light as formerly. The knowledge of alternations of generations of animals of most heterogeneous forms, belonging to the same specific types, calls for a precise understanding about their systematic names. As the question has not yet been discussed, I shall, I trust, be allowed to say a few words upon it, although it is not my intention to describe on this occasion what I know of the metamorphoses of this animal, but only to allude to its structure, reserving my account of the embryology of Medusæ for another paper.

Reviewing all the facts which have been brought to light on these points, and availing myself of my own investigations, I have shown, in my Lectures on Comparative Embryology,* that Hydroid Polypi are not simply a lower form of stemmed animals, producing at a given period more highly organized Medusæ, but that they are themselves, by their structure, real Medusæ, differing from the free forms with which they alternate mainly in their being attached by a stem, and much less in their real structure than was perhaps supposed at the time when the so-called Hydroid Polypi were still considered as members of the class of Polypi. If I am right in this respect, — if Sarsia and other naked-eyed Medusæ can no longer be considered as the productions of animals belonging to another class, — if we have really to remove the so-called Hydroid Polypi to the Medusæ proper, and simply to view them as alternate generations of these Medusæ, or as different modes of existence of animals of one and the same species, — then there can be no doubt of the propriety of describing all these phases of their development and alternate generation under one and the same generic name; by which method we shall at once

* *Twelve Lectures on Comparative Embryology*, delivered before the Lowell Institute, December and January, 1848–49. Boston, 1849. 8vo. — See also a paper read before the American Association for the Advancement of Science, held at Cambridge in August, 1849, entitled, *On the Plan of Structure and Homologies of Radiated Animals*, with reference to the systematic position of the so-called Hydroid Polypi.

get rid of the perplexity which attends the study of their complicated history, narrated as it is under so different heads. Even at present, and with all the information we already possess upon alternate generations, I find it most difficult to impress naturalists, who have devoted more attention to other branches of natural history, with the true view of this subject. No doubt, the difficulty arises from the circumstance, that, in most cases throughout the animal kingdom, all the individuals of the same species are so much alike through their whole life, as to be easily combined in one comprehensive diagnosis under a common generic and specific name. But whenever there are sexual distinctions between individuals of the same species, we begin to meet with difficulties, as there is a fatal propensity among observers to force their views upon nature, and to take this or that form as most characteristic, and to mould the description accordingly, now making the male, now the female, the type of the species; describing almost as mere occasional differences those constant and permanent peculiarities which characterize all female individuals, or *vice versâ*, as if, in different classes, males or females were more prominent in their appearance; as if it were not more correct and more in accordance with nature to mention at once, that in such species males and females differ widely, the males being distinguished by such and such characters, and the females by others, adding, if necessary, a similar description of the young.

Among animals which undergo extensive metamorphoses, the method of describing formerly employed has become altogether useless. No philosophical observer will, in future, be satisfied with a mere diagnosis of the winged state of a butterfly or a moth, when he knows how characteristic, how peculiar, and how interesting the earlier stages of growth of these animals are. I must confess that it gives to me personally as much satisfaction to watch a caterpillar, to study its anatomical and physiological characters, and investigate its zoölogical forms and peculiarities, to describe these details and compare them with similar features observed in others, as I experience in investigating in the same way either the chrysalis, or the perfect insect, or even the egg from which the whole was derived. It is a great mistake to withhold the information acquired upon these different points from our works on comparative anatomy, and to consider embryology almost as a science by itself, unconnected with zoölogy and comparative anatomy. Though the importance of such combined studies is gradually felt more and more, the best evidence I would adduce to show how little such views even now influence the progress of our science will be seen by referring to our best and most recent text-books, both in zoölogy and comparative anatomy.

But just as zoölogists have aimed always to refer their observations upon the different stages of growth of an individual species to the same systematic name, giving the appellation of Silk-worm, for instance, to that animal even in its chrysalis and moth condition, because it is best known in the form of the silk-producing worm under that name, so should we now adopt one single systematic appellation for all the phases of growth of those animals which undergo alternate generations, of course adopting as that which is to be preserved the oldest name under which the animal was first noticed, whether in its free condition or in the fixed state of its earlier metamorphosis.

I am well aware, that many inconveniences will arise from such a practice; and that names with which we are most familiar will have to give place to others less generally in use; but there is no safety in nomenclature without absolute adherence to the law of priority. Just as we discard for ever the recent appellations of so many young animals which have been of late considered as peculiar types, because we recognize them as mere embryonic conditions of well-known animals, so should we select the older name whenever we find that the adult male and the female of an animal, or the young and the adult state, have been described as two distinct species. We preserve the name of Larus marinus because it is the older, not because it is the more appropriate, of the different names under which the various plumages of our large marine gull have been described.

There can be no hesitation in the present case. The stemmed and fixed generation of our Medusa had been known and named long before its free Medusa form was ascertained. We shall therefore unhesitatingly discard in time the generic name of Sarsia, though no one is more desirous than I am to see the name of Sars proclaimed as one of those who have contributed a large share to the advancement of our science. There is, however, a difficulty in introducing at once a change in this case, since the Corynæ have been subdivided into so many genera of late, as to render it almost impossible to decide which of them should be preserved and to which all the different species now known belong. The difficulty is further increased by the claims which Dr. G. Johnston has recently raised in favor of some older names which had been disregarded by modern writers.

I would also urge the necessity of a detailed description equally complete of the various phases of life of these animals, and would propose to introduce these details under distinct heads so far as to preface the descriptions by the designations of *Proles polypoidea* and *Proles medusina*.

It is a matter of great difficulty to ascertain the specific identity or difference between animals of this class, and, I must confess, I could hardly venture to decide, in the present case, whether Sarsia tubulosa of the British coast, and those specimens which Dr. Gould has identified with the European, be truly identical or specifically distinct. There are nearly as many reasons to be given in favor of their identity as for their specific difference, and a direct comparison has not yet been possible. But if, in the perfect state, the differences are less obvious, (though, to me, they seem striking enough to justify the specific distinction,) there is such abundant evidence obtained by a comparison of the polypoid generation, in which the tentacles and ovarian bunches, as well as the form and ramifications of the stem, are so different, as to leave no doubt of the specific distinction between the European and North American Corynæ. However different or similar these species may therefore appear to different observers, so much is plain from what we know at present about them, that they are close representatives of each other in the two continents, and that, whether viewed as distinct species or as climatic varieties of the same species, we have to acknowledge in them either those limits of variations which occur between climatic varieties of the same species, or that degree of close affinity which we recognize in specific representatives of the same types in analogous climates.

Having satisfied myself of the specific distinction of the European and North American species alluded to above, I shall designate the American under the name of Sarsia mirabilis, intending to express by that specific name both the wonderful changes which this species undergoes in its metamorphoses, and my admiration of the keen observer who led the way in these investigations, and whose name I should have been most anxious to retain as the generic appellation of this type, were it not contrary to the most desirable improvement of our nomenclature.

Sarsia mirabilis in its polypoid form occurs at the bottom of Boston Harbour, and is never seen exposed, even at low water. I have obtained it only by dredging. In its Medusa form it begins to be freed early in spring, and is very abundant along the wharves all round Boston Harbour. When first freed from its polyp-like stem, the bell-shaped body is about one fourth of the size to which it grows before it has again matured its eggs; when it dies, after laying them, towards the middle of summer.

There is something quite peculiar about the duration of life of these animals, and its disappearance at that particular season of the year. This connection of the animals with the order and succession of the seasons is in itself very striking, and is particularly evinced in the lower animals, in which the duration of life itself is dependent upon the duration of the year and its changes, while in higher animals certain phenomena of life recur regularly at given periods, though their longevity seems to be more and more independent of the duration of the year and the influence of the season as they belong to higher and higher types. In Medusæ, we have not only a direct dependence of these animals upon the season for their appearance, but the length of their life is actually limited by the duration of the year; and they are as much dependent upon the seasons for their existence as most plants, or as some of the insects. They pass the greater part of the year in the more or less torpid state of egg-life, next grow into a polyp-like vegetation, which at a particular period produces a kind of bud; and this, flower-like, developes into a more highly organized structure, which is at last freed, and moves about independently. These animal flowers, as it were, (and the comparison to a flower is so striking, that, even now we know that there is nothing of a vegetable character in these animals, we cannot help using the term, as best expressing the impressions we derive from the sight of such living beings,) — these flowers move about for a certain time, until they are actually killed by the heavy showers of summer rain, — another analogy between the development of these animals and the growth of some plants.

Medusæ, of this species in particular, are very sensitive to the density of the medium in which they live, and the mere change arising from the difference in density between fresh water and salt water is sufficient to kill them almost instantaneously. Taking up in a spoonful of sea-water a fresh Sarsia in full activity, when swimming most energetically, and emptying it into a tumbler full of fresh water of the same temperature, the little animal will at once drop like a ball to the bottom of the glass, and remain for ever motionless, killed instantaneously by the mere difference of the density of the two media. This little experiment, which I occasionally repeated at different intervals during the past summer, has led me to the discovery, that the total disappearance of the small Medusæ from Boston Bay uniformly coincides with the heavy rains, while the larger species survive. Sarsia, Hippocrene, Tiaropsis, Pleurobrachia, Bolina, indeed all the small species known to occur here, disappear entirely after heavy rain-storms, a few stragglers only, which were probably moving at greater depths during the rain or concealed under more sheltered places, being found afterwards. These also disappear entirely at the next fall of fresh water. These little Medusæ occur in large numbers, swarming near the surface of the water, moving rapidly in all directions with the greatest freedom and energy. They are exceedingly voracious, and feed upon any kind of marine animals, not sparing their own species.

When kept in confinement, the water in which they are preserved should be changed frequently; but when kept in good condition they will live in captivity for a longer time; and when placed in large glass jars, they can be watched in all their movements, and very satisfactorily studied. They are, however, so transparent, that, to observe them successfully, it is necessary to place them towards the light, or to watch them at night with a candle behind the glass jar, when nothing about them can escape the attention of the observer; as the inner cavities, the tubes communicating with them, the progress of digestion, and circulation of the digested food, can be traced as perfectly as their general movements, and also the manner in which they chase their prey, seize, swallow, and finally digest it.

It is indeed a wonderful sight, to see a little animal not larger than a hazel-nut, as transparent as crystal, as soft as jelly, as perishable as an air-bubble, run actively through as dense a medium as water, pause at times and stretch its tentacles, and now dart suddenly in one direction or another, turn round upon itself, and move suddenly in the opposite direction, describe spirals like a bird of prey rising in the air, or shoot in a straight line like an arrow, and perform all these movements with as much grace and precision, and elongate and contract its tentacles, throw them at its prey, and secure, in that way, its food, with as much certainty, as could a larger animal provided with flesh and bones, teeth and claws, and all the different soft and hard parts which we consider generally as indispensable requisites for energetic action; though these little creatures are, strictly speaking, nothing more than a little mass of cellular gelatinous tissue. (Compare Plate IV. Fig. 5 to 12).

The study of such animals is therefore of high physiological importance, as it will enlarge our views of animal functions, and give more precision to our ideas of cellular life; and the more so, because in this, as well as in several other naked-eyed Medusæ, we can satisfy ourselves with the greatest ease, that the different organs which perform here different functions are entirely and exclusively composed of cells; not in the same sense as it can be said of the body of higher organisms, but strictly so, — the cells here not undergoing any extensive metamorphosis by which they are transformed into distinct tissues of different structures, though derived from cells. Here they preserve the appearance of indisputable cells, combined in various ways, slightly modified in different parts of the body, but everywhere to be recognized as cells although performing the most heterogeneous functions. Here a heap of large cells, containing a crystal-like, more consistent fluid, constitutes the main mass of the body. Other series of somewhat elongated, more or less bottle-shaped, contractile cells, elongating and shortening alternately, constitute bundles or layers of an apparently fibrous tissue, which is, however, only an accumulation of slightly modified cells representing the muscular system, and acting as such with as much energy as the striated muscles; though here we have no muscular bundles proper, no primitive fibres whatever, no striation upon the contractile tissue, but cells, the walls of which are contractile and act as muscles. (Plate V.; the parts in blue.)

Other strings of similar, but more ovate cells, constitute the chain through which sensations are perceived, and which, probably, also transmit the manifestations of the animal individuality outwards. Here other cells form the walls of a digestive apparatus endowed with the most energetic power to dissolve animal substances, and separate the nourishing from the refuse parts. Here other cells, which constitute a most powerful stinging apparatus, spread all over the tentacles, sending death into any other living creature of small size brought into contact with them. Here other cells, assuming in their combination the form of peculiar dark specks, perform, probably in a very low degree, the functions of the organ of sight, reduced, perhaps, to a faint discrimination between light and darkness. Here other cells, growing larger and larger, finally isolate themselves completely from the parent body, and give rise to new individuals.

Such is the wonderful simplicity of structure which is traced in these bodies, in which so much activity, so much energy, so many acts of decided volition, such strong appetites, such powerful movements, are constantly displayed, as might lead to the supposition that the structure was far more highly complicated and came much nearer to that of the higher animals: but upon the closest examination it is found to be made up of the simplest elements of organic structure, preserving almost completely their primitive simplicity, although in wonderfully diversified variety of combination and form. I do not know which in this organism is most wonderful, — the apparent simplicity of the whole structure; or the diversified indications of active life; or the complications and variety that the simplest elements of structure exhibit.

Our ideas of organic development of higher structures imply generally the corresponding idea of diversified systems of functions and organs, and thus we acknowledge a structural superiority of all animals in which distinct muscles, a distinct solid frame, a distinct digestive apparatus, and special organs of circulation and respiration, occur simultaneously; and we should consider as an inferior organization, that of animals in which we were to observe only simple animal walls, with one simple or ramified inner cavity. But this apparent simplicity might be counterbalanced by a great diversity of microscopic structures of the tissues; or the apparent complication of organization might be made to appear very simple, were it shown that the different tissues are simply modified cells. Such considerations respecting our estimation of the difference and resemblance which exist between animals are naturally called forth, when we remember that naturalists of high eminence have represented the Medusæ to be quite as perfect in their structure as any of those living beings which, from their resemblance to man, we have been in the habit of considering as the highest. Indeed, Ehrenberg would not grant to any animal a structural superiority over others, having succeeded in displaying such remarkable structures in many animals, which, before the publication of his investigations, were supposed to be either entirely structureless, or furnished with only the simplest apparatus.

Let it not be forgotten, now that we know more of the structure of these animals, and of their developments, that, however diversified their parts are, their tissues remain in the lowest degree of structure, — in a condition similar to that in which all animals are found at a certain period of their life when developing from the egg; and if we apply such a standard to the appreciation of the structure of the Medusæ, we shall acknowledge that they are animals of a low character of structure, although this structure be highly diversified in itself.

There is unquestionably a nervous system in Medusæ, but this nervous system does not form large central masses to which all the activity of the body is referred, or from which it emanates. There is no regular communication by nervous threads between the centre and periphery, and all intervening parts; and the nervous substance does not consist of heterogeneous elements, of nervous globules and of nervous threads, presenting the various states of complication and combination, and the internal structural differences, which we notice in the vertebrated animals, or even in the Mollusca and Articulata.

In Medusæ the nervous system consists of a simple cord, of a string of ovate cells, forming a ring around the lower margin of the animal (Plate V. Fig. 11, 2, 4, 5), extending from one eye-speck to the other, following the circular chymiferous tube, and also its vertical branches, round the upper portion of which they form another circle. The substance of this nervous system, however, is throughout cellular, and strictly so, and the cells are ovate. There is no appearance in any of its parts of true fibres.

I do not wonder, therefore, that the very existence of a nervous system in the Medusæ should have been denied, and should not be at all surprised if it were even now further questioned after this illustration. I would only urge those interested in this question to look carefully along the inner margin of the chymiferous tubes, and to search there for a cord of cells of a peculiar ovate form, arranged in six or seven rows, forming a sort of string, or rather similar to a chain of ovate beads placed side by side and point to point, but in such a manner that the individual cells would overlap each other for one half, one third, or a quarter of their length, being from five to seven side by side at any given point upon a transverse section of the row; and would ask those who do not recognize at once such a string as the nervous system to trace it for its whole extent, especially to the base of the eye-speck, where these cells accumulate in a larger heap, with intervening colored pigment forming a sort of ganglion; then, further, to follow it up along the inner side of the radiating chymiferous tubes which extend from the summit of the vault of the body, and to ascertain that here, again, it forms another circle around the central digestive cavity, from which other threads, or rather isolated series of elongated cells, run to the proboscis; they will then be satisfied that this apparatus, in all its complication, is really a nervous system of a peculiar structure and adaptation, with peculiar relations to the other systems of organs.

From this state of things as observed among Medusæ, we should be prepared to find them endowed with the power of feeling, even if the sensitive cells were more diffuse, and did not appear as continuous chains; and this is probably the condition of the sensitive apparatus in the Polyp; in which, notwithstanding the care bestowed upon a thorough investigation of the tissues, I have not succeeded in discovering any thing similar to what is so plainly seen in Medusæ. There are, however, layers or heaps of peculiar cells in various parts of the body; but only the contractile cells assume a linear arrangement, a fibre-like disposition in particular rows.

We have here, therefore, a peculiar type of the nervous system, a type different from all those types which have yet been recognized in the animal kingdom. And such a nervous system I have already traced in all its details, as here described, in the genera Hippocrene, Tiaropsis, and Staurophora. The illustrations accompanying this paper are perhaps less complete for the Sarsia, though I first traced it in this genus; but afterwards some peculiarities of the genus Hippocrene, and especially the greater facility of keeping it alive for a long time under the microscope, and of watching all the minute structural details upon the living animal, have induced me to represent them more extensively from Hippocrene than from Sarsia, which, owing to its lively, active habits, is more difficult to keep in a steady position under the microscope, unless it be mutilated to prevent it from running about.

I may mention on this occasion, that all I have to say of the structure of Medusæ has been traced upon living individuals. I do not mean upon individuals taken out of the water alive to be placed under the microscope, but upon individuals preserved alive in narrow glass jars while under the microscope, surrounded by a sufficient quantity of water to keep them alive during the whole period of investigation, and to preserve them afterwards, to be placed again and again under observation; so that comparatively few specimens have been sacrificed for these studies, though a large supply was constantly at hand, that their habits and development might be watched.

In order to study the structure of marine animals in such a way, it is necessary to plunge, without hesitation, the objective glass into the water, as it were otherwise impossible to follow with sufficient quickness the animal in its motions, or to adapt the microscope to the proper focus, if it were to be alternating through the media of air and water, or through both together. By keeping it constantly under water, a great deal of inconvenience is avoided; and, with some practice, one succeeds soon in employing in such investigations even higher magnifying powers, such as systems I. 6 of Oberhäuser's microscope, and to reserve only the highest powers for more steady investigation, with a completely immovable apparatus. Without alluding to the advantage there is in studying in this way all the tissues without destroying them by any pressure, it must be obvious that their special character can, under no circumstances, be better studied than when the tissues preserve the natural turgescence of life. Of course, such investigations cannot be traced otherwise than by the sea-side, with all conveniences for sedentary study.

The form of Sarsia mirabilis is very peculiar, and remarkably well adapted for its rapid movements. (Plate IV.) It is somewhat bell-shaped, hemispherical; with the upper vault broad and flat, and the sides rather prolonged, sometimes even in the relaxed state assuming a somewhat cylindrical form, which, when more contracted, gives the whole mass an almost hemispherical shape, which may, at times, really assume the appearance of a nearly globular body. And all these forms pass so rapidly from one into another, that it is exceedingly difficult to say which is the more natural. I have watched these animals, when they seemed to rest motionless in the midst of the waters (Fig. 1); they then had the most regular hemispherical form; the four arms, which then hung loosely downwards, would, from the base, stretch at right angles with the lower margin of the animal for a short distance, and then hang vertically downwards, for perhaps two or three times the length of the greatest diameter of the central mass. After remaining for a while immovable in that position, the walls of the body would relax, the arms elongate, the sides hang loosely downwards, and the whole body assume a more cylindrical form, when the arms hang straight downwards in graceful undulations, and without forming any marked angle with the base of the animal. (Fig. 10.) In this state of relaxation, the tentacles would elongate for three, four, and even more than five times the length of the greatest diameter of the animal; but if, suddenly starting from this inactive position, it contracts powerfully to move onwards, in its first contraction, or for several contractions repeated in quick succession, it assumes an almost entirely spherical form (Fig. 9), the thinner margins contracting more extensively than the main mass, and shutting almost entirely the lower opening of the body, the arms following in their undulation these quick contractions, which press the water out of the main cavity with such force as to push forwards in an opposite direction the whole body, which thus advances rapidly under the repeated contractions. After each contraction, and during the onward movement arising from it, the tentacles point directly backwards. During each contraction they are considerably shortened, and elongate gradually in the progress of locomotion. (Fig. 8, 11, 12.)

This animal seems very well to understand how to direct its course by its contractions, as it will dart downwards, if it be near the surface of the water when started, or it will move sideways if it be near the walls of the jar, or it will rise upwards if it be at its bottom; it will suddenly change its direction if it meets an obstacle, turn once or twice upon itself in a revolving curve, and then dart again suddenly straight forwards in any given direction. Of course, the changes of form which it assumes in these different movements are almost endless; and though several are represented in Plate IV., they hardly give a complete idea of the beautiful diversity of aspect which this animal exhibits in its movements. What increases the variety of its aspects beyond the change of form of the main body, the shortening and elongating of the tentacles, and the shutting and opening of the main cavity, is the disposition of the proboscis, which is either entirely contracted within the main cavity near its upper centre, or hangs down to the margin of the opening, or stretches out between the tentacles for nearly as great a length as the whole diameter of the body, in either a straight line, or variously bent in graceful undulations, or curved upon itself. Though the usual form of these animals is rounded, it may be seen at times to contract in such a manner as to assume a flattened shape in its lower part by the compression of its sides; and this is especially the case when the animal turns round upon itself, and changes its direction in its movements. (Fig. 8.)

Again, when it pauses and remains in that state of rest for a longer time, the lower margin is frequently seen to assume a square or quadrangular form; especially when it is perfectly immovable, and the tentacles are stretched out at right angles from the lower margin for a considerable length. (Plate IV. Fig. 1.)

On watching minutely its outline, it will be observed that the sides are not always circular, but from the contraction of the layers or bundles of motory cells, it assumes a quadrilobate appearance, especially when those radiating bundles which alternate with the alimentary tubes are powerfully contracted.

The main bulk of the body consists of a gelatinous mass, forming the bell-shaped, central part of the animal. This is thickest above in the central part of the swollen disk (Plate V. Fig. 7, 11); towards the sides it gradually tapers, and becomes very thin near the lower margin about the origin of the tentacles, where it is suddenly turned inward at right angles with its previous direction, and forms the transverse separation between the main cavity of the body and the surrounding medium, a large hole, however, being left in the centre, through which the proboscis plays at ease. This lower opening (Plate IV. Fig. 2, 3, 4) is comparatively much wider than in the genus Hippocrene, and less so than in Tiaropsis and Staurophora.

At first, when watching the animal in its movements, it would seem as if the gelatinous mass itself were the cause of locomotion; but, upon close examination, it is easily found that it is merely an elastic support for the active apparatus of motion, which consists of layers and bundles of contractile cells diversely arranged. There is an external system of these bundles immediately under the epidermis, through the agency of which the contracted body is restored to its expanded form. Upon the inner surface there is another system, which contracts the sphere, acting in antagonism with the former. These two systems consist of bundles extending vertically from the upper portion of the vault downwards. Within the inner vertical system, there is another one consisting of concentric transverse bundles, lining the cavity of the body, the direction of which tends to reduce the capacity of the space inclosed between the walls of the animal and the lower partition. A fourth system of circular concentric bundles is spread through the whole partition below. This system, in its strongest contractions, may shut almost entirely the main cavity of the body, and, like the pupil of the eye, it opens and shuts constantly. In its less powerful contractions, it assists the inner transverse and vertical muscles in reducing the capacity of the inner cavity, and when deeply contracted it helps more fully than any other part of the contractile system in forming the body into a sphere. We have thus here four distinct muscular systems, an external superficial system, an inner system parallel to the former, a concentric system of the main cavity, and a concentric system of the partition below.

It will be worth while to examine more minutely the arrangement of this muscular apparatus, as otherwise it might be difficult to form correct ideas of the movements described, and perhaps be supposed that the very existence of these muscles was not altogether so satisfactorily ascertained, if their arrangement could not be traced in detail.

Let me say, in the first place, that the outer coat of the animal consists of a layer of flat polygonal nucleated cells, forming, as it were, the external point of attachment for the external muscular system. Indeed, to this coating the superficial muscular system seems to be suspended, penetrating more or less into the gelatinous mass. The muscles, or rather the bundles of elongated cells, do not converge upon the summit. There is a circle, or rather a polygon of fibres (Plate V. Fig. 3), occupying about one third of the summit, from which vertical bundles run down to the ower margin. There are four main bundles of the kind, alternating with the eyes when seen from below. (Plate V. Fig. 4, *a*, and 3, *a*.) These bundles are the strongest of the external system; and when powerfully contracted, and especially when assisted by the inner corresponding fibres, they give the whole body a four-lobed appearance. They act in accordance with the inner system only in its most powerful contractions. In a state of repose, when the body is relaxed and the muscles slightly contracted, they however constitute a sort of antagonism with the bundles of the inner surface of the gelatinous mass. Besides these bundles, we have eight more following the same direction (Fig. 3 and 4, *b*, *b*), and occurring, also, in the intervals between two nutritive tubes, accompanying, therefore, at some distance, the main bundles already described, and bearing an evident relation to them, though far apart; as they generally follow the modifications of the main bundles, sometimes arising almost from the same point, and at other times more apart, but evidently always lending their influence, in their contraction, to the action of these bundles. Seen from below (Plate V. Fig. 4), the whole system appears rather like a brush of muscular bundles diverging downwards, then slightly converging to meet the lower margin without uniting again, and forming there twelve bundles, four of which are stronger than the other eight. By this arrangement, the bundles appear more or less pennate as they converge or diverge. I may say, that this whole system of superficial muscles is never seen, but by its action, unless the specimens are dead, and have been dead for some time, when, during the contraction which follows death, they are made temporarily visible, and can then be traced with certainty in all the details of their arrangement, under the microscope. In Fig. 3, Plate V., small transverse superficial bundles are seen, connecting the secondary vertical bundles. In the two figures of Plate V., above cited, the inner muscular systems, and the digestive and chymiferous apparatus, have been drawn in outline, in connection with the more complete and finished delineation of the system of external muscles, in order to allow a comparison with Fig. 1 and 2, where the inner muscular systems have been drawn with particular care, and the outer omitted. The possibility of thus separating the investigation of these two systems, which otherwise cover each other so closely, will satisfy every one of the necessity of close investigation of these parts to understand them well. When highly contracted, they seem to run together. (Plate V. Fig. 6, *d*, *d*.)

The inner system (Plate V. Fig. 1, 2, 11) follows closely the same arrangement, both in the direction of the fibres, running vertically from the upper centre downwards, and in their mode of diverging and converging, by which they form similar pennate bundles; except that here the central bundles *d*, *d*, *d*, *d*, are more prominent than the two accessory ones, *e*, *e*, *e*, *e*, *f*, *f*, *f*, *f*, which follow them. Though these bundles are chiefly superficial on the inner surface of the gelatinous mass, they penetrate more or less into the gelatinous body, and their arrangement is so peculiar, that it cannot be compared with the arrangement of muscular fibres in any other group of animals. As described above, the gelatinous mass of the body is bell-shaped, thickest in its upper arched part, thinnest below, where the margin is bent inwards at right angles; and this whole mass is very elastic. Now the muscular bundles can neither be said to rest simply upon the inner or outer surface of this body, nor to rise within. There are bundles which lie outside or near the outer surface, and others which lie within the gelatinous mass, and others, again, which rise more or less obliquely from within, and extend towards the surface; so that the muscular bundles are properly loose bundles, the fibres of which penetrate unequally into the gelatinous mass;

and, as the inner and outer layers correspond to each other, they form a sort of partition thr oughthe gelatinous mass, though they do not meet in the centre. The form of the bundles themselves is very peculiar, inasmuch as the isolated fibres can be traced to more or less bottle-shaped cells.

The circular system of muscles (Plate V. Fig. 11, 1, and 2, *i*, *i*), lining the main cavity of the body, covers the inner vertical system, and forms a layer of fibres placed at right angles with it. But it does not merely pass over the vertical muscles, it also covers the vertical chymiferous tubes which diverge from the centre of the disk. These muscular bundles are parallel to each other, and cover regularly the whole inner surface of the disk, there being only a thin layer of loose epithelium over them. Fully to appreciate their position and mode of action, it is necessary to have a correct idea of the relation of parts on this inner surface of the body. From what has been said above, it is plain that the inner surface is divided into eight zones; the four inner vertical muscular columns and the four chymiferous tubes, which alternate with each other, form the lines of demarcation; and between two such lines, that is, alternately between one bundle of muscles and one chymiferous tube, and so on, there are muscular fibres, extending in gentle curves all over the inner surface of the body, beginning at a short distance from the central digestive cavity, which this muscular system does not surround, down to the lower part of the disk.

That this system of concentric muscles consists of eight vertical rows of concentric bundles, and not of circular fibres extending all round the inner surface, is shown by the different forms which these parts assume during strong contraction and after death, where evidently each system of these fibres, that is to say, each vertical row between a chymiferous tube and a vertical muscular bundle, contracts independently, and in its more or less powerful contractions forms more or less arched curves; and as the whole cavity, in its contraction, has more or less curved walls when seen from above or from below, these eight rows of concentric fibres appear to intersect each other in opposite curves, and to form two distinct systems in the upper and lower half of the body. But it can easily be understood from Fig. 1, 2, and 11, Plate V., that the fibres which appear arched inwards above belong to the same system as the fibres which appear arched outwards in the lower parts. It is not difficult to ascertain that this system of fibres covers the vertical chymiferous tubes, at its junction with them, and that there are some fibres running up and down along these tubes, especially near the eye-specks upon the posterior or inner surface of their bulb, where various fibres (Plate V. Fig. 2, *o*, *o*, *o*, *o*) rise from the margin accompanying the chymiferous tube behind the bulb.

Finally, there is a fourth muscular system in the lower partition (Plate V. Figs. 2, 4, and 11, g, g); but this consists entirely of circular fibres or bundles, and these bundles constitute a continuous system all round the lower part of the body, not subdivided into distinct zones like the inner circular system, and thus showing itself to be a special, distinct muscular system. These muscles constitute a mere muscular membrane, stretched between the lower margin of the disk, and lined above and below with a single epithelial layer of very delicate cells. The muscular system itself does not consist of fibres running all round the circle, but of fibres identical with the common caudate cells of unstriped muscles, interlaced in such a manner as to form a regular membrane, the bulging part of some cells filling the space between the caudate appendages of the others; and forming in their intricate connection a flat muscular layer. It is, perhaps, easiest to trace, under high powers, the arrangement of the muscular bundles in Medusæ in this part of the body, where each contractile cell can be found to have its nucleus and nucleolus, but it requires great care not to mistake the cellular elements of the epithelium lining the two surfaces of this disk for the inner elements of muscular cells. With all the power of the best Oberhäuser microscope, I have been unable to discover the slightest indication of striæ upon the muscular cells: nevertheless it cannot be doubted that they are voluntary muscles. But it would be as unphilosophical to consider this fact as an objection to the distinction made in the higher animals, as it would be premature to infer that voluntary muscles should be striated muscular fibres everywhere in the whole range of the animal kingdom. The above description will show how widely a true muscular system, performing voluntary contractions, can differ in one class of the animal kingdom from what it is known to be in another.

The nutritive system, with its ramifications, gives a peculiar aspect to this genus, and contributes greatly to its remarkable appearance. From the mere impression derived from the powerful movements and the great activity of the proboscis of this animal, we should at once be led to suppose that it is a very voracious being, as energetic action is at least indicated by muscular power, when this has no particular reference to the swiftness of the motions. And, indeed, Sarsiæ are very voracious, and their proboscis-like digestive cavity, and their nettling appendages, are well calculated to seize upon living prey.

In the first place the nutritive system begins with a central proboscis (Plate IV. Fig. 1, 2, 3, 4; Plate V. Fig. 7, 11; also, Fig. 8, 9, 10), of considerable size and length in proportion to the bulk of the body. It hangs down from the middle of the vault, and assumes the most diversified forms in its various contractions, owing to the difference of structure of its different parts, the lower extremity (Plate V. Fig. 7, 8, 9, 10, 11, o), which is capable of the greatest dilatation, differing somewhat from the main body, b, and this again from the upper portion, *c*, of the tube, which enlarges into a central cavity, *d*. This tube, or proboscis, when contracted, does not extend beyond half the depth of the main cavity of the body. It is even at times shortened beyond this limit. In its utmost state of contraction (Plate V. Fig. 10), the lower opening, *o*, is rather widened, and the proboscis may then be compared in some degree to the mouth of other Medusæ, though its margin, *a*, is not split into lobes. When relaxed, it either hangs straight downwards or forms undulations in its course, and hangs then generally, not only to the lower margin of the main cavity, but more or less beyond. (Plate V. Fig. 7, 8, 9, 11; also, Plate IV. Fig. 1, 6 to 12.) When greatly elongated, it may even hang between the tentacles, for as great a length as the greatest diameter of the body itself.

The upper part of the tube, *c*, *c*, *c*, in the centre, is always thinner than the middle and lower portions. To this middle part, *b*, *b*, *b*, the eggs are attached. But before examining minutely the structure of this apparatus, let us follow it further. From the central cavity (Plate V. Fig. 7, *d*), into which the proboscis empties, arise four chymiferous tubes (Plate IV. Fig. 1, 2, 3; Plate V. Fig. 1 and 3, *g*, *g*, *g*, *g*; 7 and 11, *e*, *e*, *e*, *e*), at right angles with each other, which communicate freely with the central cavity, as well as with the cavity of the proboscis. These four tubes, following the inner surface of the gelatinous disk, extend to its lower margin, where they are united with each other by an annular tube of the same appearance and the same diameter, forming a circular canal (Plate IV. Figs. 1, 2, 3; Plate V. Fig. 11, *k*, *k*) around the lower part of the disk, and this circular tube communicates as freely with the vertical radiating tubes, as those communicate with the central cavity; so that digested materials and water, by which the food is dissolved, and with which it is mixed in greater or smaller quantity, circulate freely to and fro in all this apparatus. It is astonishing how quickly an animal, swallowed by this little Medusa, is dissolved, and its particles circulated. The digestion takes place above the mouth, which shuts over the food, or is simply stretched upon the surface of the animal upon which it feeds, sucking its juices and dropping soon after its dead carcass. In that way the Sarsia swallows very quickly large numbers of other small Medusæ, and especially of the young of Aurelia aurita, and also other soft animals and small Crustacea; I have, however, never seen it swallowing the hard parts of any of these latter, but only sucking their juices between these lobes.

This liquid food moves on through the proboscis in jerks to and fro, under the contractions of the tube. It even takes some time for the contents of the stomach to pass entirely into the central cavity, into which they are pushed on, mingled with more or less water. But there is a constant process of regurgitation taking place, so that particles which were once near the upper end of the proboscis are now and then suddenly eructated, or at least pressed out into the lower end of the proboscis, where the mouth, contracting closely, causes the proboscis to swell above, without allowing the food to escape, which may gradually retrace its way into the central cavity, then be circulated into the radiating tubes, reach the lower circular canal, and move about in it, sometimes advancing from the centre towards the periphery, at other times rising from the periphery towards the centre, and moving alternately one way or the other in the circular tube. There can be no doubt as to the irregularity of these movements, as the globules or granules suspended in the more liquid food will enable any one, even with a low power, to trace the course of the nourishing fluid.

The tentacles, also four in number (Plate IV. Figs. 1, 2; Plate V. Figs. 2, 4, 11, *l*, *l*, *l*, *l*), arise from the lower margin of the disk just at the points where the vertical tubes unite with the circular canal, and at these points we notice a sort of bulb (Plate V. Fig. 11, *m*, *m*), consisting of the swelling of the base of the tentacle in its connection with the chymiferous tubes, and also of a peculiar accumulation of cells, forming a rudimentary visual apparatus in the form of black eye-specks. (Plate V. Fig. 13, *a*, and Fig. 14, *b*; also, Fig. 7, *i*, and Fig. 12, *d*, &c.)

The presence of nourishment within the chymiferous system renders it more or less apparent to the naked eye. There is, however, hardly any state in this animal, in which the cross formed by the four tubular radii in their connection with the small narrow cavity and proboscis could not be distinguished, even with the naked eye. I may as well mention at once, that the cords of sensitive cells (Plate IV. Fig. 1, 2, 3; Plate V. Fig. 2, 4, 11) accompany everywhere the chymiferous tubes, so that the tracts which are made prominent to our senses by the color of the food circulated through these tubes are the most important points in the structure of these animals. The chymiferous system, in connection with the nervous system, marks, as it were, the most prominent feature of an animal, in which the muscular system alternates in the arrangement of its essential parts with these tracts.

The intimate structure of the digestive and circulatory apparatus is as follows. The proboscis consists of a tube, in which we may distinguish three layers of cells. There is an outer or epithelial layer, under which the eggs are developed, when the animal is mature. No eggs, however, are formed about the mouth, or in the uppermost part of the proboscis; the middle region of its tract alone is covered with crowded eggs, and to such an extent, that, at the spawning season, the proboscis (Plate V. Fig. 7, *b*) seems much thicker than under ordinary circumstances. The next layer consists of contractile cells; it is the most powerful layer, it is also thicker, and extends, in unbroken continuity, from the margin of the mouth to the central cavity. (Plate V. Fig. 8, *c*, *c*.) It is a kind of muscular tube, in which, however, the tissues do not assume a membranous appearance properly, but rather preserve their cellular nature. On the inner surface, we find another layer of epithelial cells, *i, i*. The contraction of the cells of the middle layer can be seen so easily under the microscope, that, if any doubts should be entertained upon the question of cells, as such, being organs of locomotion, I would simply refer to an investigation of this proboscis. There are, however, some peculiarities about which I am not prepared to give a decided opinion. For instance, are the threads which extend between these contractile cells contractile fibres or sensitive fibres? As for the walls of the central cavity and the radiating vascular tubes, as well as the circular tubes below, they seem structureless; that is to say, the elements of which they consist cannot be traced beyond the main appearance, which is that of very thin membranes, and whether they are intercellular spaces lined with solidified gelatinous matter, or whether they are particular rows of cells, confluent into each other so as to form tubes, I cannot determine at present. But so much is true, — that the whole system of these peripheric tubes communicates in all its parts, and that the movement of the fluid within is not owing to the contraction of the walls of the circulating tubes, but is produced by the contractions of the proboscis, in which there is a distinct muscular layer, and by the general changes of form arising from the contractions of the voluntary muscles, and also from the contractions of the tentacles, which, by their base, are connected with the circulating apparatus. And although we have here a regular alimentary canal, and this canal branches off and assumes the appearance of a circulatory system, we have properly neither a digestive system, in the sense in which we acknowledge it in other animals, nor a circulatory apparatus; for there is no distinction between the alimentary canal proper and the vascular system, the one opening through large tubes into the other; nor is there a distinct circulatory apparatus, as the fluid circulated in these tubes consists of the contents of the stomach which have been emptied into them. Therefore we should be on our guard against comparisons involving identity of plan and of structure, when tracing the analogies or homologies between these parts. As far as I am concerned, I would prefer to call the central part of this system the proboscis, rather than to call it the mouth and stomach; I would prefer to call the narrow cavity above, the central, circulatory cavity, rather than to call it the heart, and I would prefer calling the vessels arising from it chymiferous tubes, to calling them either bloodvessels, or circulatory vessels, or alimentary vessels.

Another fact, which shows how little, — I will not say, homology, — but how little analogy, there is between such an arrangement of tubes and that of the vessels of higher animals, is this, that the sensitive swelling, — as every body will allow the eye-speck with its bulb to be, even though its being an organ of vision should be denied, — that the sensitive bulb is so closely connected with the marginal tentacles and the chymiferous tubes, and is placed in such a radiating position along the margin of the animal, as to form an apparatus unparalleled in the animal kingdom.

The tentacles of the margin (Plate V. Fig. 2, 4, 11, *l*, *l*, *l*, *l*; Plate IV. Fig. 1, 2) have a structure very similar to that of the proboscis. They likewise consist of contractile cells, and also have cells of a peculiar character upon their external surface; but the degree of contractility is far greater in these tentacles, for they can shorten to a length considerably less than the diameter of the body, and extend to four or five times that length; and the quickness with which they retract and extend is most astonishing. These tentacles are hollow, and the liquid which circulates in the circular tube penetrates into their cavity up and down. They are gradually attenuated and nearly cylindrical when extended, but rather thick when contracted. There is not the slightest indication of an aperture or puncture at their end, through which fluid might be absorbed, or refuse matter from the chymiferous system rejected, nor is there any such opening in any part of the circular tube or of the other tubes through which the liquids are circulated.

The external surface of the tentacles (Plate V. Figs. 11, 12, 15, 16, 17; Plate IV. Figs. 1, 2) appears rough, granular, or rather tubercular; and, when elongated, these tubercles are sufficiently distinct to appear like rows of beads hanging loosely to several threads twisted together. But in their contracted state they come so close together, that the whole surface of the tentacle appears tubercular. Upon close examination, these tubercles are found to consist of heaps of minute epithelial nettling cells, arranged in the form of rosettes or mulberries, each of which contains within itself a thread coiled in a spiral, which may be thrown out like the threads of all nettling cells, and is provided at its base, or at the upper portion of the bulb formed by the cell, with a double hook. Similar cells occur, not only upon all the marginal fringes of the discophorous Medusæ, but even upon the tentacles of the margin of their mouth. I have, however, suppressed in this paper the graphic illustrations of their structure which I had prepared, having since discovered a highly complicated structure in similar apparatus in Polypi, which leads me to suppose that the structural details hitherto recognized in the nettling apparatus of Medusæ do not exhaust the subject. I foresee, indeed, that there are material additions to be made to what has just been mentioned, as soon as another opportunity is afforded to examine specimens of this animal. But whether their structure shall be found more complicated than it is at present supposed to be, or not, so much is certain, that the nettling cells, forming the bead-like granules upon the tentacles of Sarsia, throw out, under artificial pressure, long threads, by which they no doubt seize upon their prey; as it is never observed that they coil the whole tentacle round any animals which they strike to death apparently by simple contact, and which remain adherent to the part of the tentacle with which they have been struck. This shows plainly that the nettling cells themselves, with their threads, must be the seizing apparatus; and though I have never seen, in the living animal, the threads turn out of the cell in this species, and have only noticed it in specimens acted upon by pressure, I have recently observed the fact of the inversion of the nettling cells in Polypi so distinctly, that I have no doubt as to the identity of the operation in both cases.

The discovery of these nettling lassos in so many animals provided with tentacles, and which had never been seen to use their tentacles to secure their prey, but which seemed rather to retain it by some magic power, will at once account for all the difficulties. Though the tentacles taper uniformly for their whole length, they are comparatively rather thickened near the base, where their swollen wall forms a kind of support for the numerous minute pigment-cells which constitute the bulb of the eye, among which a few pigment-cells, of a larger size, grouped closely together, constitute a dark, brilliant speck upon the outer and upper part of this bulb. This is another curious adaptation in nature, where the organ of sight is combined with one which is destined to catch the prey, and where the main apparatus for distinguishing at least between light and darkness, if not for perceiving distinct images, is imbedded in a heap of cells, which form also part of the thick wall of the tube through which the fluids circulate. This combination is so remarkable, that it is worth while to pause a moment and consider the particular disposition of this bulb, its intimate structure, and its relation with the different parts around it.

The sensitive bulb, as I may call it (Plate V. Figs. 12, 13, and 14), is placed, as already mentioned, at the junction of the marginal tentacles and the circular vertical tube, which pass into each other on their inner surface. It forms a marked projection, and is of an irregular triangular form, with rounded edges. Seen from below (Figs. 2 and 4), it is divided into two halves bulging sideways, between which the marginal tentacles arise (Fig. 13). Seen in profile (Fig. 13), the dark eye-speck appears still more prominent, in the shape of a hemispherical body projecting above the base of the tentacle. Seen from above and outside (Fig. 14), it is more pear-shaped, the vertical tube, *a*, above the eye-speck appearing like a continuation of its upper end. The circular tube (Fig. 13, *c*) opens sidewise towards its lower margin, and so far behind its edge as to appear less connected with it on each side when seen in front. (Fig. 12.) The whole mass of the swollen bulb consists of various kinds of pigment-cells, and other cellular uncolored tissue, which may be an accumulation of sensitive cells; for the nervous tissue, or rather the circular nerve, which follows the marginal circular tube, enters on both sides of the bulb (Fig. 2, 4), within its substance. And as this nerve itself consists simply of a string of ovate cells, I have scarcely any doubt that the transparent cells distributed among the pigment-cells of the bulb are sensitive cells, as well as those which are arranged in a distinct cord around the inner margin of the circular chymiferous tube. In the centre and on the outside of the bulb, there is a heap of larger pigment-cells grouped together so closely as to form a distinct, dark speck, which may be considered as an eye proper, or rather as the apparatus which absorbs the light, and transmits it to the sensitive elements of the tissue underneath. That such an eye, if it be an eye, cannot properly be compared to the eyes of higher animals is plain, from the fact that the dark pigment is placed here between the light and the nervous mass, and therefore rather intercepts the image than receives it. But it may act as a condenser of light, and give rise to different sensations in the dark, and under the direct influence of light. We may, therefore, consider such an organ as a rudimentary eye, perhaps incapable of perceiving distinct images, as there is no transparent lens to refract the rays of light, and combine them in a focus. But in the transition between such dark specks of pigment matter connected with nervous masses, and regular eyes or ocelli, there are so many intermediate stages of structure in the animal kingdom, that it were unphilosophical to deny the connection between the function which such an apparatus performs and the functions of ordinary eyes.

The difference, however, is sufficient to warrant the introduction of another distinct appellation, and justifies us in designating such imperfect apparatus of vision as "eye-specks." It has been said, that they might be apparatus adapted for the perception of heat rather than light; but when we reflect how slight is the change of temperature of the medium in which these animals dwell, we are less inclined to take such a view of this organ, and we would only acknowledge that the perception of the calorific rays of light without a distinct perception of the colorific rays might be none the less a sort of vision, if we reflect upon the intimate connection there is in nature between heat and light, and if we further consider, that, in the series of animal structures, we pass from apparatus clearly constructed as eyes to those in which these organs, becoming more and more numerous, appear on the surface of the body, rather like parts of the system of their coloration, and therefore also as parts of their adaptation to be more or less influenced by different sorts of rays of light. When describing Hippocrene and Pleurobrachia, I shall have an opportunity to show how little ground there is for considering these dark specks as organs of hearing.

I have little to add upon the nervous system, after what has been remarked above. Its structure is the same wherever it occurs in naked-eyed Medusæ, consisting of ovate cells, arranged in strings, which are, however, more elongated in Sarsia than in Hippocrene. The main cord is that which extends along the lower margin of the body, forming a circle close to the inner side of the circular chymiferous tube. This cord, however, is not continuous all round the animal, as the four sensitive bulbs are interposed in its circumference. We should therefore view it, in this type, as four strings connected by four ganglia, in which the thread-like arrangement is lost in the mass of the bulb. As for its position, it follows the inner margin of the chymiferous tube, and may be easily recognized upon any point of the circumference, close to that tube, on its inner margin; near the bulb it rises distinctly towards its base on its posterior side, into which it merges. Contractile fibres placed on the sides of this ganglion, and a thickening of the substance of this part, prevent a clear perception of the sensitive elements in their connection with the bulb; but parts of this system rise along the vertical tubes on their inner side, and follow their whole tract up to the central cavity, around which they form another ring, connecting the four vertical threads and encircling here, again, the central parts of the alimentary cavity. From this upper ring, thread-like cells may be traced downwards along the proboscis; and, as already mentioned, I am almost convinced that they follow the whole tract of the proboscis between the epithelial and muscular cells. Again, along the main bundles of vertical muscles, there are similar threads, which seem also to belong to the sensitive system, and to unite with the circular cord below, between the main bulk of these bundles, at their origin from the lower margin.

The resemblance, however, between the many variations of form in the contractile cells, (from the appearance of mere caudate cells to that of bicaudate cells, or mere thread-like cells,) and the numerous modifications of a similar kind observed among the sensitive cells, is so close, that I do not yet venture, in every case, to distinguish between them; so that, among these various sets of apparatus, which I have referred to two distinct systems, there may be some of the elements which belong truly to but one system, and it will require still more extensive investigations to decide with any certainty whether the proboscis is provided with sensitive cells at all, and whether the threads between the muscular cells are also muscular, or whether the shorter cells between the vertical, muscular bundles are nervous cells. Even some cells joining the upper ring, and accompanying it, may be only motory cells, and not sensitive elements.

But whatever be the final result of the investigation upon these few points, so much is already ascertained, — that there are rows of sensitive cells distinct from the contractile cells, though their constituent elements are very closely allied in their structure; and that the main cord of the sensitive system extends round the lower margin between the eyes, and is connected with other cells forming a row behind each vertical tube, and another row round the central digestive cavity; and that distinct muscular contractile cells occur in four different systems, following different courses, which are easily distinguished in the main from the sensitive cells.

After arriving at such results, and upon comparing the elements of these tissues with each other, and finding them so near alike, it may even be questioned whether there is so strict a distinction between their functions in these low animals as we notice in higher types. And I should not be at all surprised, if it should be ascertained that even the cells of the circular, sensitive cord below contract in the motions of the animal, as well as the truly muscular cells; and if these cells, in their turn, should be found to enjoy the power of feeling or perceiving impressions similar to those which act upon the truly sensitive cells. So much, at least, is certain, that the nettling cells, which are truly epithelial cells, are capable of contracting or throwing out the coiled thread within them, and of being excited to perform their functions; — which would indicate in them, also, a certain degree of sensitiveness. Indeed, there is no philosophical ground for considering the structural elements in any way more distinct from each other in their nature, than their real structure warrants, which is throughout cellular; and where we have animals of a large size, living as these do, and performing such complicated functions as these are known to perform, without any other constituent elements besides cells, there is no reason to consider each set of these cells as absolutely distinct in its functions. I would mention in particular, that I have ascertained, by direct observation, that many of the threads which Dr. Will has described as connected with the upper ganglion in Beroe, are contractile threads, notwithstanding their connection with a distinct ganglion. Should it be objected, that this would only go to show that Dr. Will has mistaken muscular fibres for nerves, so much would remain clear, — that here muscular tissues combine intimately with nervous tissues, a mode of combination unknown in other animals. This circumstance, at all events, goes to support the view which I entertain of the subject in general, that the elements of structure in Medusæ have not yet reached that degree of distinctness and independence which they present in other groups of the animal kingdom.

There is another point in the structure of Sarsia which deserves particular notice. Above the central cavity may be observed a little knob rising into the gelatinous substance of the upper portion of the disk, brightly colored, and somewhat resembling the four bulbs of the lower margin, consisting, as the bulbs themselves, of a number of pigment-cells. The form of this knob varies in different individuals of this species, according to their size and age. In the youngest, when about a line in diameter, just when they are freed from their hydroid polypidom, it has the form of an acute cone, reaching to the very surface of the dome-shaped disk, while, in more and more advanced individuals, it grows broader; the pointed summit is reduced, and finally this knob appears as a more or less hemispherical mass above the central cavity. This organ is a sort of umbilicus; it is the remnant of the canal by means of which the Medusa bulb was attached to its hydroid polypedon, and which undergoes the change just described, as soon as the connection has been broken between the maternal stem and the young animal.

This knob seems to me analogous to that black organ, which, in Beroid Medusæ, has been considered as a central eye, or as an organ of hearing, and below which a ganglion is seen. It remains to be ascertained, by embryological investigations, whether, in Beroe, this eye-like bulb is developed in the same manner as the knob of hydroid Medusæ, and whether it undergoes there, after detachment, a higher development to assume the appearance and functions of an eye-speck. That this may be the case seems probable, when we consider the relation of the two sorts of apparatus in the two types. The upper nervous ring in Sarsia bears the same relation to the central alimentary cavity and to the pigmented disk, that the ganglion and eye-speck of Beroe bear to the chymiferous system, which opens above its gelatinous disk notwithstanding these openings.

As for the organs of reproduction, I have already mentioned that eggs are developed along the greater part of the proboscis, between the muscular cells, and the external epithelium. These eggs have the same structure as all primitive eggs, being nucleated cells of a peculiar kind, destined to acquire greater independence, and to be cast, after their germinative dot and vesicle have grown to a certain size, and the transparent yolk inclosed in the vitelline membrane has been transformed into a granular, cellular mass; when they are extruded by the repeated contraction of the proboscis, and are dropped to undergo their independent development. But upon this point I shall enter into more details in another part of this paper.

One of the most instructive anomalies which I have observed in the genus Sarsia is a modification in the number of parts which I have once noticed in the common species of these shores. Though I have examined many hundred specimens of the Sarsia mirabilis, I have always found it to present the most uniform arrangement of its parts, the specimens having, in every instance, shown four eye-specks, four radiating tubes, and four bundles of radiating muscles, on the outer and on the inner surface of the disk. But, in one instance, two specimens were noticed, among many others, in which the parts were arranged in six (Plate V. Fig. 5); there were six tentacles, six eye-specks, six radiating chymiferous tubes, and six bundles of muscles. The specimens were somewhat larger than the common four-rayed specimens, the disk measuring about half an inch; and I for a moment suspected this to be a distinct species; but, upon close examination, I found that every part was so perfectly identical with the corresponding parts of the four-rayed individuals, that I not only failed to discover the slightest specific distinction, but should even feel unwilling to recognize this as a variety. I should rather view it as a mere accidental modification of the number of parts, of no more importance in the range of specimens than the accidental development of an additional spur on the foot of a cock, or an additional finger to the hand or paw of an animal; — perhaps more striking here, as it ran through all the systems and influenced the general appearance of the whole body. But wherever we have an additional number of parts, we see everywhere that those tissues and systems of organs which belong to such parts are naturally developed in it; and so it was in this six-rayed Sarsia.

The six eye-specks were all identical in the details of their structure, and identical with those of the four-rayed ones. The connection between the circular tube and the radiating ones was the same, and the muscular bundles presented the same arrangement in relation to the lower margin, and intervening radiating tubes, as in common specimens. But if these six-rayed Sarsiæ had no importance whatever with reference to specific distinction, they were none the less of great interest with reference to the value of the number of parts in different genera of the same family of naked-eyed Medusæ. For, if a change in number, such as was noticed in this species, can occur without a modification of the specific character, we shall be prepared by this example to consider those genera in which the number of rays, or tubes, or ovaries, or eye-specks differs, as more closely allied than would otherwise appear. A variation in the number of parts in this family, when the parts are otherwise identical in structure and adaptation, will no longer be considered as a natural foundation for distinguishing families. They may indicate distinct genera, if the differences in number are combined with some modification in adaptation. But, however constant the differences in the number of parts may be, if they are not combined with some special adaptation in one or the other of the systems, I should not consider them even as warranting generic distinction, as we see in the case before us that such differences do not even warrant specific distinction.

This case of Medusæ with different numbers of rays is precisely parallel to the case of star-fishes with a variable number of rays, such as have been described by the older Linck, who, unfortunately for himself and the progress of science, considered each variation in this respect as indicating generic distinctions; when he might easily have ascertained that several species vary greatly in this respect.

HIPPOCRENE.

I have selected the genus Hippocrene for a special consideration of the naked-eyed Medusæ, for the very obvious reason, that it can most easily be managed under the microscope when alive, owing to its smaller size, and also, in some degree, to its peculiar form, which makes it easier to keep it in a given position. This genus was established nearly simultaneously, and quite independently, by two different authors. Mertens, during his voyage round the world, saw a species to which he gave the name of Hippocrene, which was described and figured in the Transactions of the Imperial Academy of Sciences of St. Petersburg, for the year 1835. Lesson, on the other hand, described it in the *Annales des Sciences Naturelles*, under the name Bougainvillia.*

All we know at present of the structure of this remarkable genus is to be gathered solely from the sources just mentioned, and from Lesson's work on Acalephæ, forming one of the continuations of Buffon, published by Roret. Professor Forbes has added most valuable information upon the British species. There is, however, one point in the history of this animal as yet entirely unsettled. The other naked-eyed Medusæ seem to be all derived from hydroid Polypi, but the generation of Hippocrene has not been sufficiently traced to have led to the knowledge of its alternate generation; and though I have seen its eggs laid, they are so minute as to escape the attention of the naked eye, when dropped into water. The suggestion I have made,† that Hippocrene might be the free generation of Tubularia, rests simply upon certain analogies between the germs developed in the ovarian bunches of Tubularia and the full-grown Hippocrene, and by no means upon a direct investigation of its metamorphoses. It remains, therefore, to be seen, whether Hippocrene is really the alternate state of existence of Tubularia, or whether it originates from some other hydroid Polyp.

That Hippocrene should be one stage of generation of some hydroid Polyp is made more probable, since the true relations of this little Medusa with Sarsia and other naked-eyed Medusæ have been fully ascertained, and I expect that it will be found to be

* Although Professor Edward Forbes, in his *Monograph of the Naked-Eyed Medusæ*, has preserved the generic name of Lesson in preference to that of Mertens, upon due consideration I am inclined to go back to the name of Mertens; for, though Forbes mentions the year 1829 as the date of Lesson's genus, I cannot find any definite indication of its establishment prior to the year 1836, in the *Annales des Sciences Naturelles*. It is true Lesson was the first to describe the species upon which this genus rests; but he established it under the name of Cyanea Bougainvillei in Duperrey's *Voyage round the World*.

† *Lectures on Comparative Embryology*.

a universal character of this family, to multiply alternately by eggs producing polypidoms, and by buds arising from these stems to produce free Medusæ. The genus Hippocrene is easily recognized by its hemispherical form, its four bunches of tentacles, with numerous eye-specks at the meeting of the vertical tubes with the circular marginal one; and also by its quadrangular, pendulous, central digestive cavity, from the margin of which hang numerous branching fringes. This general appearance of Hippocrene is so peculiar, as at first to suggest the propriety of separating it into a distinct family; but upon tracing the homologies between all parts through the whole family of naked-eyed Medusæ, it cannot escape the attention of the philosophical observer, that all these animals form members of a natural, intimately connected series, and that it would be a gross exaggeration of the differences which they exhibit to subdivide them into families. The main features are in all the same. There is a central cavity (Plate I. Fig. 1–4), here somewhat larger and much shorter than in Sarsia, from which arise four radiating chymiferous tubes which meet along the lower margin, with a circular tube of the same character, precisely as in Sarsia. Through this system, the digested food is circulated, and the granules floating in liquid move to and fro from what might be called here also a stomach, through the radiating tubes, into the circular one below, and back. There is nowhere an inlet or outlet to this system, excepting through the mouth, which is surrounded by numerous tentacles, branching repeatedly. These tentacles are only the fringed margin of the mouth itself, and should, therefore, not be considered as something peculiar to Hippocrene; nor is the mouth in any way peculiar, as it forms here, as in all other naked-eyed Medusæ, a circular radiating opening.

The most striking generic peculiarity of this type is the pendulous position of the stomach or proboscis when seen in profile (Plate I. Fig. 1), which neither enjoys the great power of extension and contraction which characterizes Sarsia, nor is reduced to the small size peculiar to Staurophora, nor so pressed against the upper disk as in Tiaropsis. It is here a square mass, more or less star-shaped in its outline, when seen from above (Plate I. Fig. 3, 4), or from below (Fig. 2); not longer than it is broad, but which, morphologically speaking, answers strictly to the proboscis of Sarsia. The analogy is the greater from the position of the sexual apparatus in the two genera; eggs and spermatic cells arising in both only from the external walls of this central organ. The color of the stomachal bulb, however, is very peculiar, inasmuch as in different individuals of the same species it is either pale-yellow, or orange, or simply purple and brown; no doubt this coloration is owing to peculiar cells lining its inner surface, which may have something to do with digestion, and perhaps may be analogous to hepatic cells, though I have been unable to satisfy myself on this point.

The origin of the four chymiferous tubes, which arise from the upper corners (Plate I. Fig. 1) of this cavity, shows still further the intimate relation there is between the structure of Hippocrene and that of the other genera of the family. Perhaps the arrangement of the tentacles might be a more difficult point, as in Sarsia we have only one long tentacle, with one eye-speck at the confluence of the vertical and circular tubes; while in other genera, such as Tiaropsis and Staurophora, there are many isolated tentacles all round the lower margin of the disk, larger ones alternating with smaller ones, either each provided with an eye-speck, or only the larger ones, or the eye-specks alternating with the tentacles. But if we take into consideration the curious genus Lizzia, of Forbes, where there are alternately two and three tentacles more closely united, with a single eye-speck to each bundle, there will be no longer any difficulty in acknowledging in Hippocrene only an extreme in the combination of tentacles, grouped altogether in four bunches, with the additional peculiarity of having as many eye-specks as there are tentacles; — an extreme, I say, of the arrangement foreshadowed in Lizzia, where fewer tentacles form similar bunches. Thus we are gradually led to consider as belonging to the same series those naked-eyed Medusæ in which the tentacles are arranged in a single row, as Thaumantias, Willia, Circe, Oceania, Turris, Stomobrachium, Geryonia, and Geryonopsis; and those in which they are combined in bunches, as Lizzia and Hippocrene; and those in which they are reduced to a few isolated tentacles, as in the genera Sarsia, Slabberia, and Modeeria; and even those in which there is one single tentacle developed, as in the genera Euphysa and Steenstruppia.

A thorough comparison of the other generic peculiarities throughout this family will sustain equally well my position, that the naked-eyed Medusæ constitute a single natural family; and that the modifications noticed in different genera are only generic modifications, and not indications of distinct families. The fact that the tubes branch before they reach the circular tube, as is the case in Willia, is of no greater importance than the fact, that individuals of the same species may have a larger or smaller number of such tubes. For though generally the number of these tubes is constant in one and the same species, we have seen Sarsia mirabilis with six rays, six tubes, six tentacles, and six eye-specks, and the bundles of muscles follow the same general arrangement, according to the fundamental number displayed in those specimens, just as the number four prevails in others. Of how subordinate importance this ramification of tubes may be will appear still more evident, when we take into consideration the diversity there is in that respect among the common discoid Medusæ. And, also, to refer to genera of this very family, we cannot but be struck with the little importance of these ramifications as the foundation for families, when we compare the genera Berenice, Staurophora, and Eudora.

The question about the value of the position of the ovaries is one of great importance. In Sarsia and Hippocrene, we have the eggs developing upon the external walls of the proboscis or central digestive cavity. In Tiaropsis, Thaumantias, and others, we have the ovaries on the outer surface of the radiating tubes, while in Staurophora we have them in an intermediate position. This last fact shows the little importance there is in the position which the sexual organs assume in these animals; for, even if we had not this intermediate disposition in Staurophora, I would not hesitate to bring together genera like Slabberia and Sarsia, which can hardly be distinguished as genera otherwise than by the disposition of the ovaries; and though Circe has eight radiating tubes, and eight ovaries, this difference does not remove it in the slightest degree from Thaumantias. Circe and Thaumantias are as nearly allied as genera of the same family can be, and, indeed, between them there is no other difference than in the number of radiating tubes; and we know already, from Sarsia, that this is of little value. Saphenia, also, when compared with Oceania, may show the slight importance these numbers have; for the value of the genus Saphenia as a generic section may fairly be questioned, when we see Oceania with four, with eight, and with more tentacles, the chief generic character of Saphenia being to have only two such appendages.

Now if the position of the ovaries around the central part of the digestive cavity, or upon its radiating tubes, is not a character of sufficient importance to warrant a distinction of higher order than a generic distinction, we can be led to a more natural arrangement of the genera of this family than that proposed by my friend, Professor Forbes; but I do not wonder, that, with all his philosophical acumen, he has been led to exaggerate the value of these characters, for he first pointed them out, he first recognized these fundamental differences, and we all know that the first step in the recognition of facts is to exaggerate their value, and that we hardly come to a correct appreciation of their real importance unless we have exaggerated them. This kind of natural exaggeration is, after all, the only test of the value of facts; and I have no doubt, that, in his own mind, and probably by the progress he has made since he gave the scientific world the admirable results of his investigations, Professor Forbes himself must have found that the distinction of six families among naked-eyed Medusæ does not rest upon the existence of six fundamental types of structure, but upon various combinations of the fundamental elements of one very natural group, for the recognition of which we are indebted to him.

Though groups more or less similar to that of the naked-eyed Medusæ, as circumscribed by Professor Forbes, have been introduced in former works upon the natural history of this class of animals, — though we have in Eschscholtz the families of

Geryonidæ, Oceanidæ, Æquoridæ, Berenicidæ, which constitute his natural group of Discophoræ cryptocarpæ, answering closely to that of Forbes's naked-eyed Medusæ, — it is now obvious that Eschscholtz's division of Discophoræ cryptocarpæ rests upon the ignorance of their true mode of reproduction, rather than upon any fundamental common character; and though he alludes to the absence of what he calls the eight marginal granules, which we now call eye-specks, and which are known to exist also, but in another form, in the naked-eyed Medusæ, still this division rests altogether upon an imperfect knowledge of these animals. Lesson himself, though his work is published at a period when so many facts had been ascertained respecting the structure of Medusæ, did not recognize the common structure of this type, and subdivides it into various families without a common character.

The characters common to all naked-eyed Medusæ consist, in the first place, in the general character which they have in common with all other Discophoræ, to which great order of Medusæ they belong, implying the existence of a gelatinous disk, and a central digestive apparatus. In the naked-eyed Medusæ, this gelatinous disk is generally more hemispherical, and less flattened than in the larger Medusæ with protected eyes; also, as far as I can ascertain, all naked-eyed Medusæ have a continuous circular tube, into which open the few radiating vessels which arise from the central cavity of the digestive system. It is true, in the common Discophoræ, there is also a marginal connection of the radiating branches of the chymiferous system. But there it is rather an anastomosis of minute vessels, while here we have a regular circular tube, in which fluids move to and fro, and into which the radiating tubes open largely. This circular tube forms so prominent a feature in the structure of the naked-eyed Medusæ, that it marks out the lower or peripheric margin of the animal, and that the eye-specks, tentacles, and all the various ornaments of the margin of the disk seem to be connected with it, or to arise from it, or to be more or less dependent upon it; and, indeed, from the large supply of nourishment constantly circulating in the circular tube, I have no doubt that the life of the parts surrounding it is more active and intense than that of any other part of the body, owing to the regular, fresh supply they receive from the digestive cavity. The main cord of the nervous system itself is connected with this circular tube, and follows it on its inner margin all round. Muscles in vertical bundles outside and inside of the gelatinous disk regulate the locomotion, assisted by a system of circular fibres upon the inner cavity, and another within the partition, which stretches more or less extensively from the lower margin inwards. Tentacles, varying extraordinarily in number and size and arrangement, arise from this same lower margin, and the eye-specks themselves are placed in the same position, either between the tentacles, or upon their base, or their inner or outer surface.

In Sarsia, for instance, they are upon the outer surface of the base of the tentacles; in Hippocrene, upon the inner surface.

Another character common to all naked-eyed Medusæ consists in their central mouth. Though many of them have been described as deprived of such a central aperture, there can no longer be any doubt respecting its existence in all the well-characterized genera of the family. Extensive differences may be noticed in the form of the mouth, and in its connection with the inner cavity, but these differences are nowhere such as to warrant more than generic distinctions. In Staurophora, it is a mere fissure, in the form of a narrow extensive cross in the centre of the lower surface of the disk, with low fringes all round its edges. In Tiaropsis, the opening is reduced to a small space in the centre, but the margin of the mouth forms more extensive lobes, with thin, light fringes. In various genera, this central cavity forms a sac more or less developed, hanging from the centre, either with a simple margin, or with a lobed and fringed opening. This central sac may assume a more permanent shape, as in Hippocrene, or be of a more movable nature, as in Thaumantias, or even be developed into a very protractile and retractile proboscis, as in Sarsia. In Hippocrene, we have perhaps the maximum of division in the margins or lips encircling the mouth, as they form here a kind of dichotomous tentacles; while in Sarsia the margin of the mouth is entire. Again, the organs of reproduction are found in all, upon the outer surface of the digestive cavity, whether they encircle the main, central cavity, or follow the radiating tubes.

The characters of the naked-eyed Medusæ may therefore be easily summed up in this way. A gelatinous disk with a reëntering margin; — a central digestive cavity with radiating tubes meeting a circular tube along the margin; — tentacles and eye-specks along this margin; — mouth and central cavity varying in size and form, but opening in all in the centre; — reproductive organs following the chymiferous system; — and a distinct nervous ring along the circular marginal tube observed in all; — generation alternate, one form Polypoid, and the other Medusoid.

After having characterized the genus Hippocrene as above, and traced its intimate relation to the diversified forms referred to the type of naked-eyed Medusæ, I shall now proceed to illustrate the minute structure of this animal, which I have been able to investigate satisfactorily in almost all its details. Form and structure are so intimately connected in these low animals, I may say in Radiata at large, that the one is almost the expression of the other, in a far more strict sense of the word than in any other group of the animal kingdom. And this is so true, that giving a complete description of their form is already to intimate the general arrangement of their organs, and that the description of their organs can never be full, unless it is mentioned in relation to their form.

We should, therefore, not wonder at the fact, that the zoölogical descriptions of the lower animals include so much more of structural details than the descriptions of any other group of animals. The truth is, that here it is impossible to characterize genera or even species without alluding to structural details, just as it is hardly possible to give a sketch of their structure without indicating the principal varieties of form under which these animals appear. And it is of great importance for the progress of zoology in general, that this should be the case; for, as the study of radiated animals has, of late, excited more interest than before, it will have a beneficial influence upon the other branches of zoölogy, in carrying over into all its departments the methods now employed in the description of these lower types; when the results of comparative anatomy and embryology will be united to form one great picture of the whole animal kingdom, as is already the case in the study of Radiata.

It is really an unexpected circumstance, that the investigations of the lowest animals should lead to the most appropriate and natural method of studying, describing, and depicting animals at large. But if we consider how, in these Radiata, and perhaps in Medusæ more than in any other group, the changes which they undergo during life are intimately connected both with their habits and changes of structure, it will be obvious that the study of their metamorphoses is entirely inseparable from the study of their structure, and that, again, this study is intimately connected with that of their habits; so that, in this class, the natural history of these animals is truly what it should be in all classes, an illustration of their form, of their structure, and of their embryonic development, as well as of their respective habits. It is highly desirable that this method of studying animals should be universally introduced; and as soon as it is done for those classes which, from their peculiar structure, have left remains of their former existence buried in the strata which constitute the crust of our globe, another point of view will equally be connected with those other considerations, — I mean, the study of fossils; when those isolated doctrines of natural history, comparative anatomy and physiology, embryology, and paleontology shall be viewed universally as mere subsidiary departments of one science, — that of the development of life.

In Hippocrene the form is particularly striking, and there is hardly any type among the naked-eyed Medusæ in which it preserves a more permanent appearance; for this animal, during its motions, is less liable to extensive changes in its outline than any other genus.

The gelatinous disk which forms the main mass of the body is so much bent over downwards, and its margin so extensively bent inwards, as almost to close the body, and to give it nearly the form of a regular sphere. (Plate I.) The contraction of the disk below, and the width of the partition across the lower opening, prevent both an extensive spreading and very powerful contractions, in consequence of which the movements are reduced to repeated jerks, and the whole animal seems rather to jump from place to place by its sudden contractions, than to dart in one direction and to bend in various ways, as the Sarsia does, or to progress slowly by repeated uniform contractions, as we observe in Tiaropsis and Staurophora. In its natural position when at rest (Plate I. Fig. 1 and 5), Hippocrene stands upright in the water, its tentacles more or less drawn out and stretched outside at various angles from the lower margin. The tentacles, however, in that position, may be more or less contracted. When fully drawn out (as in Fig. 1, 2, 5, 6), they are longer than the diameter of the body itself; but when fully contracted (as in Fig. 4 and 11), they are very short and hardly visible isolately, but form simple bunches of curved threads. If immovable, with retracted tentacles, the animal seems to sink slowly lower and lower in the water; but with the tentacles stretched out, it remains more steady in the midst of the water, and does not seem to change perceptibly its place. As soon as it contracts to move, the tentacles are reduced to a certain middle state of extension (as in Fig. 3), and brought together in a backward direction (as in Fig. 9 and 10); but when dilating, they are drawn in through the lower aperture in an inverted position (as in Fig. 7 and 8). From its peculiar form, this animal turns easily every way, and moves with equal ease and elegance sideways or downwards, or obliquely in all possible directions, as Fig. 7, 8, 9, 10, 11, show. The arrangement of parts, however, is such, that, during the most powerful contractions, the lower opening is brought into a square form, as noticed in Fig. 2, 3, 4, 9, 10, but when gradually relaxing passes again into a more rounded shape, as in Fig. 1, 5, 8, 11. When at rest, as in Fig. 1, it is perfectly circular, and only the more straight course of the inferior chymiferous canal, extending from one sensitive bulb to the other, preserves some indication of the quadrangular outline. As far as I know, the species of Hippocrene which lives on the shores of Massachusetts is the smallest perfect Medusa known. At least, I have not observed any species with perfectly developed eggs of so small a size as this. Fig. 5 to 11, indeed, though intended to give a correct idea of this animal in its natural appearance, have been enlarged to twice their natural diameter, or at least exaggerated one half, as I have never seen a single specimen fully equal in size to Fig. 11. But, as it would have been almost impossible to give any thing like correct outlines of this little creature without enlarging it, I have preferred to exaggerate somewhat its size, even in drawing its natural attitudes, rather than to omit such details as will alone give a correct idea of its particular appearance. Fig. 1, 2, 3, and 4, represent some of its attitudes considerably enlarged. Fig. 1 is a profile view, slightly turned, to show, through the transparent mass, the parts of the whole body in their natural position. Fig. 2 represents a specimen seen from below, looking into the main cavity of the body, with all the tentacles fully drawn out, in order to show the lower opening, the mouth, and its tentacles, the main digestive cavity, and the four rays which arise from it, and curve downwards to reach the four bulbs, from which the tentacles arise. In this figure it is plainly seen that the tentacles are inserted upon a triangular, or somewhat crescent-shaped bulb, and that there is an eye-speck at the base of each on its lower surface. From this bulb the tentacles diverge somewhat in the form of four bunches, and, on comparing this figure with the upper figure, it is easily ascertained that the tentacles are stretched upwards in such a manner as to form a sort of radiating arch stretching upwards and outwards, the bulb being then slightly turned outwards. Between the four bulbs, a canal is observed assuming an almost quadrangular form, though its four sides are slightly arched outwards. The respective position and relation of these parts are further well shown in Fig. 1, where the large, central brown bulb represents the central digestive cavity, which is nearly quadrangular, or almost cubical with prominent angles, and from the lower corners of which arise four bunches of tentacles surrounding the mouth, which last is placed in the centre of the lower surface, as seen in Fig. 2. The angles of the mouth project in the same direction as the bunches of its tentacles, which are also developed in the same direction as the four chymiferous tubes arising from the upper corners of the digestive cavity, so that the radiation of all parts takes place in the same direction. These four radiating chymiferous tubes first rise upwards, and are then arched over sideways, to turn downwards and finally meet the four sensitive bulbs below, following in their course the inner surface of the gelatinous mass. This mass has a prominent rounded discoid projection upon the centre of its lower surface; thus causing the central digestive cavity to hang, as it were, downwards into the main cavity of the body, though in fact it arises, as in other genera of this type, upon the lower surface of the gelatinous disk. But this surface being not uniformly arched, but prominent in its centre, the parts seem to have here a very different arrangement; and, had it not been ascertained, by a vertical section through the centre, that the middle portion of the gelatinous disk bulges downwards, it might have been supposed that the central digestive cavity was hanging loose below the disk, and was suspended to the four radiating chymiferous tubes.

The branching tentacles of the corners of the mouth hang downward, in their natural position, as seen in Fig. 1. They are naturally foreshortened in Fig. 2, where they are seen from below. The difference shown in these two figures in the form of the sensitive bulbs and in the fringed eye-specks arises, also, solely from the position of the animal.

They are seen in profile in Fig. 1, and appear to form a flatter arch than in Fig. 2, owing to the oblique position of the bulb, and the circumstance that the tentacles, with their basal eye-specks, are inserted upon its prominent edges. The waving lines which are observed in Fig. 2, 3, and 4, between the bulbs and outside of them, indicate the different layers of muscular bundles lining the main cavity on the inner surface of the gelatinous disk. Seen in profile, as in Fig. 1, they appear like vertical supports, curved somewhat in the form of the letter S. The undulated outlines of the cavity in its upper part, between the arches of the chymiferous tubes, arise also from the undulations of the muscular system around the bulging projection of the centre of the gelatinous mass. Fig. 3 and 4 both represent the same animal seen from above; but the differences noticed in the central mass arise from the circumstance, that, in Fig. 3, the main digestive cavity is quite empty and contracted, and assumes there the form of a cross, with short arms, from which the radiating chymiferous tubes arise above, as the tentacles of the mouth arise below; while in Fig. 4 the main digestive cavity is filled and dilated, — so much so, that its prominent corners pass almost insensibly into the radiating tubes; and what gives it the appearance of a still larger organ is the circumstance, that its lateral walls are covered all over with minute eggs. It was, no doubt, owing to the presence of egg bunches alternating with the prominent corners of the mouth, that Mertens, in his description of this genus, has characterized the central cavity or stomach, as he calls it, as formed of eight distinct suckers, four larger and four smaller ones, alternating with each other. But the central cavity is really square, and has only four prominent angles, and this appearance of eight suckers arises simply from the development of eggs, which are formed between the prominent angles of the main cavity, upon the outer surface of its lateral walls. Moreover, these figures differ the more, as in one of them, Fig. 3, the tentacles are partly retracted, and in the other, Fig. 4, completely drawn in.

I need not say, that I have found it very difficult to ascertain the true relations of all these parts. Whoever will take the trouble to compare my figures with those of other species of this genus will, no doubt, acknowledge that I have spared no pains in endeavouring to make out the real structure of these minute, soft-bodied animals. As mentioned above, their slow movements, and their habit of resting quietly, suspended in an immovable position in the midst of the water, have somewhat facilitated the investigation; and their habit of remaining quiet, at times, when turned upon their side, or even when reversed, with the lower opening upwards, has been an additional advantage in this study. I may say, that I have been successful in investigating all parts in their natural relations in the living animal, with powers as high as Ocular 1, Objective 6, of Oberhäuser's microscope, and that I could apply any higher powers after cutting the body into halves; for thus, without being sensibly altered, it would spread enough to admit of its being placed under glasses of very short focus. Some details, however, were examined from fragments cut entirely free.

As there are few systems of organs so conspicuous in the body of Hippocrene as the digestive system, I shall begin the minute descriptions of the parts of this animal with an illustration of this apparatus, as a knowledge of its arrangement is the best preparation to trace further the relations of other systems, and their combinations. Mertens was undoubtedly correct, when he ascribed a mouth to the genus Hippocrene; and Brandt, in his more extensive description, when publishing the notes of this able observer, was no doubt mistaken when he supposed that the fringes arising from the main central cavity were a kind of suckers, by which the animal pumped its food in a liquid state. I have, over and over again, seen the central mouth opening and shutting, and assuming the most different outlines, as it contracted or expanded; and, from a microscopic investigation of the surrounding tentacles, I can positively say, that they are deprived of any kind of opening at their termination, and are simply organs of prehension.

When shut, the mouth forms a prominent tubercle (Plate II. Fig. 18, *a*), between the four bunches of tentacles, presenting a fissure in the form of a cross upon its apex. This proboscis-like protuberance is a sort of protractile and retractile lip of whitish cellular tissue, which, from its great transparency, is easily overlooked upon the dark ground of the central cavity. This transparent tissue, however, forms the whole surface of the central cavity (Fig. 18, *b*, *b*, *b*, *b*); it extends, also, sideways into the peduncle of the tentacles, and rises upwards along the corners of the quadrangular mass, but it is really capable of considerable dilatation and contraction; for, though the mouth may be protruded so as to bulge out between the tentacles for nearly half the diameter of the central cavity, as represented in Plate II. Fig. 18, it spreads, at times, into a flat, nearly star-shaped opening, as seen in Fig. 23, *b*, with a more or less undulating margin. In this form the lips are considerably attenuated, and a narrow central cross-shaped fissure (Fig. 23, *c*) appears in the centre as the entrance (Fig. 23, *a*) to the central cavity. When examined from above in such a state of dilatation, as the upper wall of the central cavity is very thin, it is easy to see through it, and the opening appears then as a small four-rayed star, as in Fig. 19, 20, 22. The same appearance is also observed from below, as drawn in Plate I. Fig. 2. But the mouth is capable of a still further dilatation, when the narrow central opening is spread to the same extent as the lips, and the whole inner surface of the central cavity is seen through the opening, as in Plate II. Fig. 21. In such a state of dilatation, the mouth is almost square, and nearly as wide as the main cavity, the lips being more or less sinuous. (Fig. 21, *a*.) In this condition of utmost dilatation, the continuity of the transparent mass of the lips with the base of the tentacles, *b*, is very obvious. The peduncle of the tentacles itself appears then simply as a prolongation of the mouth, protruded in the form of a branching margin. Here, the analogy of the mouth with that of the common Medusæ, such as Aurelia or Cyanea, is very obvious, the only difference being, that the branching fringes are not so membranous, but rather dendroid.

The tentacles of the mouth, (Plate II. Fig. 18, *c*, *c*, *d*, *d*; Fig. 21, *b*, *c*, *c*, *c*; Fig. 23, *d*, *d*, *e*, *e*, *e*; Fig. 25, 26,) like the lips, consist of a transparent cellular tissue, composed of two layers of different cells. The inner layer, which forms the main stem and the centre of the branches, consists of larger polygonal cells, (Fig. 25, 26, *b*, *b*, *b*,) while the outer layer consists of much smaller stinging cells, (Fig. 25, 26, *c*, *c*, *c*,) provided with an inner arrow-head (Fig. 27), like all nettling cells. Around the top of the branches of the tentacles, these latter cells are arranged in bunches, in such a manner as to give each termination the appearance of a sucker. But even when employing the highest magnifying power, I could discover no trace of an opening, but only the stinging cells in their regular arrangement. That these tentacles cannot be organs of suction is plainly shown by the fact, that their branches are not hollow, but consist of continuous cells. Their function, as indicated by their structure, can only be that of retaining the prey. The number of terminal ramifications in each bunch of tentacles is about one hundred, each tentacle dividing first into two branches, which are somewhat unequal, and then subdividing dichotomously, but also somewhat irregularly; for each of the bunches of the second order is subdivided so far as to contain, one about twenty, and the other about thirty terminal branches; amounting together to about one hundred terminal points in each tentacle, and making, therefore, about four hundred of these branches around the mouth. Each of the tips is surrounded by about a dozen stinging cells, varying in number according to the size of the branches, being more numerous in the larger branches and fewer in the smaller ones, and more numerous in old specimens than in younger ones. When fully open, as described above, the mouth allows a sight into the centre of the digestive cavity, which appears as an undulating surface, with honeycomb-like irregular depressions, (Plate II. Fig. 21, *e*, *e*, *e*,) lined with an epithelium of a dark-brown color. Whether the deeper brown cells under this epithelium are to be considered as hepatic cells, and whether these little depressions are secreting cavities, I am unable to decide; but I should incline to suppose that there are active functions going on in these tissues, and that the different layers of these cells do not perform the same functions, as the cavity contains always mucosity mixed with brown matter. The cross-like figure in the bottom of this cavity, as seen from below when the mouth is open, (Plate II. Fig. 21, *d*,) indicates the folds in the roof of the digestive cavity, from which the radiating tubes arise.

The digestion takes place very rapidly; for the same specimen which, when brought in from the sea, had this central space widely distended, as in Plate I. Fig. 4, showed it soon after reduced to a more contracted star-shaped body, as in Plate I. Fig. 2 and 3, and Plate II. Fig. 22, where *b* indicates the empty cavity, *c* its prominent angles folded together, and *a*, *a*, the four prominent external corners. The upper corners of the central cavity are narrowed into the four radiating tubes, as seen in Plate I. Fig. 1, 2, 3, 4, and in Plate II. Fig. 18, 19, 20. Their connection with the main cavity seems not the same under all circumstances. When the central cavity is very full and distended, the tubes seem to be almost direct continuations of the main cavity, as in Plate I. Fig. 4, and to taper gradually into the tubes above; but when contracted, the communication between the central cavity and the tubes is nearly closed, and the tubes seem to arise like ligaments from the upper surface of the cavity, as seen in Plate I. Fig. 3.

Owing to the various dilatations and contractions of this part of the main cavity, its prominent corners assume various outlines. They appear, when half distended, like the rays of a star, as in Plate II. Fig. 19, 20; and then their continuation into the tubes is almost direct, though a slight contraction may be noticed at the base of the tubes, as in Plate II. Fig. 20. In this state, when the main cavity is partly empty, the areolar structure of the inner surface may be noticed equally well from above, through the wall of the body, as from below, through the opening of the mouth; as is shown in Plate II. Fig. 19, 20. There can be no doubt, therefore, that the whole inner surface of the central digestive cavity has the same structure, and performs throughout similar functions. But this areolar structure, and the lining epithelium, with the brown cells underneath, disappear at the base of the radiating tubes, and through their whole length nothing similar is noticed. Their walls consist of a homogeneous transparent tissue, through which the digested food is seen to circulate.

The fact that these tubes may be shut at their base, and thus temporarily cease to be connected with the digestive cavity, shows that the food is not admitted into them before it has undergone a certain degree of elaboration. But no sooner has it been reduced into a certain state of fluidity, in which the particles of the nourishing materials appear like little globules, than they open, the nutritive fluid passes into the radiating tubes, circulates regularly through these tubes along the inner walls of the disk, and through them passes into the circular tube around the lower margin. I have never seen in this species a regurgitation of the digested materials into the main cavity, and it hardly could be visible through the opaque walls; but I am disposed to admit that such a backward current discharges, from time to time, the refuse materials into the main cavity. Indeed, undulatory movements of the globules (Plate II. Fig. 20, *b*, *b*) suspended in the liquid are frequently seen in the upper part of the tubes, and the contents of the main cavity hardly leave any doubt respecting the fact, that the undigested materials return to this cavity to be discharged through the mouth. If, upon these facts, we attempt to form a precise idea of the nature of the process of digestion and circulation of the nutritive fluid, we remain satisfied that the food introduced into the stomach is there transformed into chyme, under the influence of the epithelial coating and of the secretion issuing from the brown cells which line that cavity and form the inner layer of its tissue; and that when transformed into a homogeneous mass, or into chyme, it is discharged into the radiating tubes, and circulated through the body.

The fluid thus circulated and used as nourishment, and assimilated by the parts to restore their deficiency, to increase their tissue, and to contribute to the growth of the animal, is not blood; nor is it crude food; it is chyme, properly speaking, but chyme which is circulated, like blood, through a regular system of vessels. But these vessels cannot be compared to blood-vessels, nor this circulation to a regular blood-circulation; for the tubes communicate directly with the main digestive cavity, and the fluid circulated discharges its refuse parts back into that cavity; so that we have here a circulation *sui generis*, and a nutritive fluid also *sui generis*, which can only be compared to chyme. For if we take the most comprehensive view of circulation, and include under this function the distribution of nourishing fluids of every kind, then we must say that the lowest stage of development of the blood, the lowest condition in which that fluid is circulated, is that which answers to the chyme of higher animals; and this view will be justified, however strange it may at first appear, by a further comparison of the fluids circulated in the vessels of other animals, if we reflect that, in Articulata and Mollusca, even in those which have a heart, the fluid circulated is not blood properly, in the same sense as the blood of Vertebrata, but chyle. If these views are correct, we should be justified in saying that, in Radiata, *chyme* is circulated; in Mollusca and Articulata, *chyle*; and in Vertebrata only, *true blood*. This view is further sustained by the microscopic examination of the circulating fluid, which consists of globules most heterogeneous, both in respect to their size and their intimate nature, being merely comminuted particles of the digested food.

As for the tubes themselves, they form, for the circulation of the chyme, a closed system, which consists of four tubes arising from the upper corners of the central digestive cavity, and uniting at the lower margin with another tube running round that margin.

The vertical tubes do not form so simple an arch as in the genus Sarsia; for in Hippocrene the lower surface of the gelatinous disk is not simply arched; but there is in its centre a more prominent knob, below which the central digestive cavity hangs. This knob, with the central cavity, forms, therefore, a very prominent mass in the centre of the main cavity of the body; and the chymiferous tubes, which arise from the upper corners of the digestive cavity, have first to ascend along the gelatinous protuberance, and then merely bend over in a narrow arch before they descend along the lateral walls of the main cavity to reach the base of the sensitive bulb. The curve which all these four tubes describe is that of the crosier. (Plate I. Fig. 1.) As the upper portion of the disk scarcely ever changes its form, but slightly contracts and dilates, we perceive no marked change in the curve of these corners, and the changes in the direction of the current of chyme are consequently less frequent than in Sarsia.

To these immovable central parts of the animal, we must, no doubt, also ascribe the special adaptation of the central digestive cavity, which is precisely the reverse of that of Sarsia. In Sarsia, the extremely elongated form of this cavity allows it to be used as a proboscis, stretching in all directions for the food, and snapping at it with the greatest quickness and precision. Here the same organ is changed into a square, immovable, large cavity, the opening of which is capable of a most extensive dilatation, and surrounded by immovable branched tentacles, the surface of which is covered all over with nettling cells, by the agency of which the prey is retained. The appendages of the border of the mouth, by their peculiar structure and power of dilatation, perform in Hippocrene the same office with reference to securing the prey as the exceedingly active proboscis of Sarsia, which is, at the same time, both a catching apparatus and the digestive cavity. The chymiferous tubes are nearly as apparent upon the disk of the animal as the central digestive cavity, the nourishing fluid which is circulated in them being generally of a light-brown color. The position of the tubes within the main cavity is also characteristic. They are not attached loosely to the inner surface of the gelatinous disk, but follow its more permanent outlines, being kept steady both by the muscular bundles which extend in a circular arrangement round that surface, and by the epithelium which lines it. Their position is properly between this circular or concentric layer of contractile muscular cells, and the gelatinous disk itself, alternating with the main vertical masses of muscular fibres. Yet these tubes are not a mere furrow or canal hollowed out between other tissues: they have distinct walls of their own, which are exceedingly thin, structureless, homogeneous, and transparent, consisting of a hyaline membrane, in direct continuation, however, with the walls of the central digestive cavity, as may be seen from Plate I. Fig. 1 and 4, and Plate II. Fig. 7, 8, 9, 10. Their diameter is uniform for their whole length.

It is, however, at times more or less distended, owing to the greater or smaller quantity of fluid circulated in them. The lower part of the vertical tube is movable to some extent, inasmuch as it is situated along that portion of the gelatinous disk which alone is subject to considerable movement by the contraction of its muscular bundles. This lower portion of the tubes, however, is generally curved outward, (Plate I. Fig. 1,) so that it does not meet the base of the sensitive bulb from above, but from its inner surface, as is well shown in Plate I. Fig. 1, and in Plate II. Fig. 11, *e*, 13, *b*, and 17, *d*, *d*. It might seem at first as if the bulb at the base of these vertical tubes was a mere sac placed between the vertical tubes and the circular one of the lower margin, and it has really been described as such a pouch or sinus; but nobody, so far as I know, has as yet perceived that there is a connecting tube between the four bulbs. Neither Mertens, nor Brandt, nor Lesson, though all claim originality for their investigations, has seen any such connection, and Professor Edward Forbes himself does not seem to have noticed it, though he has known such a circular tube to exist in other allied genera. Now this circular tube in Hippocrene is situated in the same relative position in which it occurs universally in other naked-eyed Medusæ, extending in a circular disposition from bulb to bulb, (Plate I. Fig. 2, 3, 4; Plate II. Fig. 11, *b*, *b*, 13, *a*, *a*, 14, *e*, *e*, and 17, *a*, *a*,) and forming along the lower margin a continuous canal. Along the inner margin of this tube, the nervous cord is distinctly seen, under no very high power of the microscope, as shown in Plate I. Fig. 2, 3, 4; Plate II. Fig. 11, *a*, *a*, 14, *f*, *f*, and 17, *b*, *b*. But as here the eye-specks and tentacles are grouped in four bunches, the circular tube is stretched more directly from one bunch to another, and though arched outside, it assumes an almost quadrangular form. In it, as well as in the vertical tubes, the circulation of most heterogeneous granules, moving to and fro in all directions, and up and down through the vertical tubes into the horizontal circular one, can easily be traced, even under low magnifying powers.

So little is known of the structure of these animals, that I do not suppose that any particulars respecting it will be thought superfluous, and I may, therefore, be permitted to dwell at greater length upon the connection of the vertical and horizontal tubes with the sensitive bulb. This very prominent part in the little Hippocrene, which to the naked eye appears like a tuft of threads with dark specks at the base, consists of very heterogeneous organic elements. In the first place, I may say that it is by no means hollow, as it has been supposed; that the tentacles themselves are also not hollow; and that there is no direct communication whatsoever between the bulb and the chymiferous tubes. The fact is simply, that, as a normal organic adaptation in all these animals, the sensitive apparatus follows closely the disposition of the digestive and circulating apparatus. And, as I have already mentioned above, all these systems of organs are everywhere in direct relation with the very form of the animal. But if there is no organic communication between the tubes and the bulb, we should not overlook the circumstance, that, before reaching the base of the sensitive bulb, each vertical tube, as figured in Plate II. Fig. 8, is dilated, and divides into two tubes, *b*, *b*, which are the connecting branches of the circular tube; or, in other words, on the inside of the inner surface of each sensitive bulb, there are three tubes meeting in a common triangular dilatation, (Fig. 8, *a*,) and this sac-like dilatation rests upon the inner surface of the sensitive bulb, and constitutes the connecting ampulla between the vertical and circular tubes. (Plate II. Fig. 11, *e*, *b*, *b*, and 13, *b*, *a*, *a*.) It does not seem to me that this sac-like dilatation is to be considered as any thing more than a mere swelling of the tubes at their point of junction; but I can easily conceive how such swellings may be found of larger dimensions, assuming the functions of pulsating sacs, or becoming a kind of heart, which would be here chymiferous hearts, in contradistinction from chyliferous or blood hearts of the higher animals. But the vascular swelling of Hippocrene is so small, that it can hardly be considered as such. It is rather a varicose dilatation of the tubes themselves; and, though I have noticed that this cavity is at times wider than at others, I have been unable to see it beat.

The whole chymiferous system, therefore, consists here of the four vertical tubes and the circular tube, without any ramifications into the tentacles, containing a fluid which is circulated to and fro in all directions. How nutrition is effected by this apparatus cannot easily be appreciated, unless we assume that there is an active process of endosmosis going on between this cavity and its contents and the surrounding tissues. The intimate connection of the sensitive bulbs with the nourishing system is so striking, that I cannot but insist again and again upon this feature in the structure of these animals. No doubt there is an organic connection between them more intimate than the mere relation of apposition; for the branching of the tubes corresponds with the swelling of the nervous cord into the large ganglia, and the dilatations of the chymiferous system, which might in some respects be considered as chymiferous hearts connected with the inner surface of the sensitive bulb, show further a more mutual dependence of these parts. Whether the circular tube should be considered as one tube, or as four distinct tubes extending each from one bulb to another, and meeting there with the vertical tubes, is a question of no importance whatever, as soon as it is understood that there is a free passage from each vertical tube, in two opposite directions, into the circular tube below, and also a free passage behind each bulb from one arc of the circular tube to the other, as may be inferred from Plate I. Fig. 2, 3, 4, and seen in Plate II. Fig. 8, 13.

The nervous cord, following closely the course of the circular chymiferous tube, is placed along the inner margin of that tube. It can easily be seen, either from above or from below, whenever a perfect view of the whole circular tube is obtained, and is actually drawn as a thread with double outlines in the figures above quoted, as well as in those representing the muscles, and more particularly in Plate II. Fig. 11, *a*, 14, *f*, 16, *c*, and 17, *b*, *b*. Under a low magnifying power, this cord appears simply as a thread following the chymiferous tube. (Plate I. Fig. 2, 3, 4.) When I first noticed it, it appeared to me as a small thread; and though its structure was not fully recognized then, its connection with the sensitive bulbs led at once to the appreciation of its real nature as the main cord of the nervous or sensitive system. The difficulty of distinguishing between the tissues in this part of the body where so heterogeneous organs meet together, has rendered it for a long time difficult for me to ascertain the real nature of this cord. For here we have also circular muscles, or contractile fibres, which move the transverse partition of the lower part of the disk; we have an outer and an inner epithelium; and finally, the walls of the chymiferous tubes, which, at times, present themselves with so strongly defined outlines, that when the tube is not in its natural position, but more or less twisted, the sensitive cord does not appear on its margin as a distinct thread with peculiar outlines. But all the conditions for correct investigation of the facts having been assumed, I have repeatedly satisfied myself and others, that there is, along the inner margin of the chymiferous tube, a cord differing in its microscopic structure from all the contractile fibres and from all the epithelial cells around it, which follows the whole course of this circular tube, and enters into the lateral corners of the sensitive bulbs, where it forms part of their mass.

This cord, examined under high magnifying powers, such as Ocular 3, Objective 8, of Oberhäuser's microscope, appears as a string of several rows of nucleated cells, ovate in their form and placed with their longer diameter in irregularly continuous lines (Plate III. Fig. 13); that is to say, the cells are not strictly placed in juxtaposition by their ends, but alternate more or less, so as to form a cord-like mass, the elements of which are ovate cells placed side by side, their tips interposed between each other. This arrangement and the form of the cells make it easy, after the organ has once been seen, to recognize it again in whatever position it may be observed, and of late I have frequently been able to trace it upon the circular tube, passing obliquely across it, or following it in an oblique direction, whenever the parts had been twisted. Tracing this cord for the whole course of the circular tube, we see it penetrate into the angles of the sensitive bulbs, (Plate II. Fig. 11, *a*, *a*, 14, *f*, *f*, and 16, *c*,) in which its cells mingle with colored pigment-cells in such a manner as to form a compact ganglion of heterogeneous elements, rather than a nervous bulb. Of this, however, presently. Let me first remark, that in Plate III. Fig. 14, the nervous cord, *c*, is figured as it is usually noticed between the other organs; *a* being the sensitive bulb, *b* the chymiferous tube, *c* the sensitive cord, and *d* the muscular partition of the lower side of the body. Fig. 13 of the same plate represents a portion of the same cord freed from all the surrounding tissues, with its well-characterized isolated cells of somewhat unequal size, and irregular, though chiefly linear, arrangement.

As for the bulb when seen with the naked eye, it appears simply as a dark speck, (Plate I. Fig. 5 to 11,) from which the tentacles issue. Under a moderate power, say of from ten to twenty-five diameters, it appears like a crescent-shaped projecting mass, (Plate II. Fig. 11 to 17,) thickest towards its base, thinner towards its prominent margins, and varying in apparent form in consequence of the different positions which it assumes. When stretched out laterally, (Plate II. Fig. 12, 14, 16, and Plate III. Fig. 14,) it is almost crescent-shaped or semicircular; and specks are noticed along its margin at the base of each tentacle. The substance, also, of the bulb presents then a regular arrangement, the pigment-cells being disposed in conical masses, with their points turned towards the black dots, while their wider bases unite in a semicircular dark mass. The same appearance is observed, whether we look at the bulb thus stretched from above or from below. The radiating cones of dark pigment-cells, however, are more distinctly seen from below, as is evident from Plate I. Fig. 2, or Plate II. Fig. 12, 14, 16, and Plate III. Fig. 14, when contrasted with Plate I. Fig. 3, 4. Seen from the edge in that stretched position, the tentacles being bent downwards, (Plate II. Fig. 13,) the position of the tentacles, which extend further inward on the upper side of the bulb than on the lower side, prevents a correct appreciation of the structure of the bulb. The black specks, however, which are placed on the lower surface of the tentacles, shine through, and form a double curve of black spots, the middle of which stands higher than the lateral parts, for a reason which will be obvious presently. If the tentacles are raised, but the bulb remain in the same position, (Plate II. Fig. 11, and Plate I. Fig. 1,) the basal part of the bulb is easily distinguished, and the black specks appear clearer, as they are now seen directly. In this position it can easily be ascertained that the chymiferous tube is really distinct from the bulb, and placed behind it, and that the nervous cord, Fig. 11, *a*, *a*, reaches the bulb on its inner lower margin.

Seen from the edge, (Plate II. Fig. 11 and 13,) the bulb appears narrower, or is not so high as broad. In this position, especially when the tentacles are raised, (Fig. 11,) the whole relative arrangement of parts is most distinctly seen. The chymiferous tube, as well as the sensitive cord, *a*, *a*, is traced to the base of the bulb, and the somewhat triangular ganglion, *c*, of the base, which is faintly seen in Fig. 13, is here more strongly marked. Seen from below and fully stretched out, (Plate II. Fig. 14,) the triangular ganglion, *d*, *d*, is still more clearly seen, and the radiating pigment-cones most distinctly noticed. The black specks, Fig. 14 and 16, *a*, *a*, *a*, form a curved series arising from the lower margin of the bulb at the base of the shorter outer tentacles, where they are smallest and nearest the chymiferous tube. They gradually recede, however, more and more from the base of the tentacles, rising upon a slight prominence of their lower surface, and growing larger and larger, till we observe the largest at the base of the longest of the middle tentacles, with a very prominent black speck. When contracted laterally (Plate II. Fig. 15), as constantly occurs when the animal shuts its lower opening by the contraction of the inferior muscular partition, the bulb is folded up, and then divides into three unequal masses, the middle folds following the margin of the longest tentacle, and the two lateral masses answering to two bunches of lateral tentacles. When, on the contrary, it is fully spread out, but seen from the edge, as in Plate II. Fig. 13, it is almost triangular, or rather flat crescent-shaped, its surface is smooth, and the specks are seen through the tentacles. From these observations, it must be plain that the bulb is not hollow, but that it consists of a mass of dense cells arranged in a particular way. A triangular dilatation (Plate II. Fig. 14, *d*, *d*) at the base inwards consists more of sensitive cells, upon which are arranged, in a somewhat semicircular disposition, small, dark pigment-cells, grouped together towards the periphery to form prominent cones, the points of which are surrounded by more transparent parenchymatous cells, which form the base of the tentacles. The eye-specks at the base of the tentacles are not directly connected with the pigment-cells of the bulb; they form more compact and darker dots by themselves, in little prominences of the lower surface of the base of the tentacles, as seen in Plate II. Fig. 1, *a*. The accumulations of pigment-cells, which constitute the eye-specks, appear either as spherical or as circular disks, and assume at other times an ovate shape, or even the form of crescents. These various appearances must be the consequence of the arrangement of the cells, for they are always more or less circular, when seen from above or through the tentacles (Plate II. Fig. 13), and they assume a more crescent-shaped form when the tentacles are raised and the eye-specks are seen from the edge. I conceive, therefore, that they have the form of watch-glasses, lining the sac-like projection of the base of the tentacles, and that the crescent-shaped appearance arises either from the curve of the projection at the base of the tentacles, or from the circumstance of their being seen more or less in profile, or from both circumstances combined. But one thing is plain, — and a very important circumstance it is, — that the pigment-cones (Plate II. Fig. 12, 14, 16) of the bulb point to the centre of the eye-specks, which shows a close connection between these dark dots and the centre of the bulb where the nervous ganglion is seated; and though this is not an arrangement known in the organs of vision of any other animals, we are at least reminded by these peculiarities of the structure of the compound eyes of insects, in which the pigment-pillars intervening between the nervous mass at the base of the eyes present a structure not very different from that of the radiating cones in the bulb of Hippocrene; and I cannot help finding in this analogy an additional argument in favor of the opinion which considers the marginal specks of Medusæ as a visual apparatus. The supposition that the eye-specks of Radiata may be organs of hearing seems to me, indeed, entirely set aside by the peculiar arrangement of the sensitive bulb in this genus.

The tentacles themselves are transparent threads, capable of extraordinary dilatation and contraction, although they consist exclusively of cells. When fully elongated (Plate I. Fig. 2), they appear like very thin undulating threads stretched out in a radiating manner; the middle and longer ones, however, always rise above the lateral ones, which are shorter. These bunches of tentacles seen from above or below appear like a brush of threads; but when seen in profile, it is plain that the middle ones are arched over the lateral ones, and hence the very different appearances which the animal with extended tentacles may present in different positions, when the tentacles are more or less raised, as may be judged from the appearance of Fig. 1, 2, 5, and 6, Plate I. The more the tentacles contract, the thicker they appear, and in their contractions they assume also a more undulating or curved appearance, as may be seen in Fig. 3 and 4, in the latter of which they are so much contracted as to form a short bunch of thick threads round the eye-specks; and in this contracted state the tentacles are again straighter than in a half-expanded position, as may be noticed in Plate I. Fig. 4. The dilatation or contraction of the tentacles does not take place through their whole length simultaneously, for the base may be elongated and the upper portion still contracted, or the extremity may be elongated and the base in a contracted state; or the middle portion alone may be swollen, and the base and tip elongated. And these contractions and dilatations take place in rapid succession, the tentacles being rather active; but though displaying such an activity, and such a power of dilatation and contraction, — evidently voluntary movements, — they consist wholly of cells of two different kinds; one row of large cells (Plate II. Fig. 2, 3, 4, *a*) forming the main trunk of the tentacle, the cells being either arranged in single rows, or encroaching upon each other irregularly; while much more numerous smaller cells (*b*, *b*) form a uniform coating over the whole tentacle. The contractile organ of the tentacle doubtless consists of the inner row of cells; for these change their shape considerably in the different forms of the tentacles. When fully contracted, as in Plate II. Fig. 13, they are narrowed into transverse fibres, and seem to be transverse muscles. But when elongated they are like square masses, the longitudinal diameter of which is scarcely half their transverse diameter, as in Fig. 3, *a*. Both forms, though less contracted, may be observed in Fig. 14, where the cells are broader in the elongated part, *c*, *c*, of the tentacle, and narrower in its contracted portion, *b*, *b*.

The outer coating consists of several layers of minute nucleated cells, some of which among the superficial ones are more prominent, giving the tentacle a ragged appearance under a high magnifying power. Among these cells, there are some minute ones, probably stinging cells, the nucleus of which is like an arrow-head, though I have not been able to see any of them throw out their arrows, as they do in Sarsia.

The tip of the tentacles (Plate II. Fig. 2, 4) is rounded, and there is no trace of an aperture or puncture, the whole extremity being surrounded by these small superficial cells. The last cell of the interior row, by its hemispherical form, precludes all supposition of a central canal in these tentacles. The terminations of two of these tentacles are represented in Plate II. Fig. 2, 4; and the elongation of these cells, especially as seen in Fig. 2, can leave no doubt respecting the correctness of the view I have expressed above, that this middle row is the active portion in the contractions of the tentacles. This description leaves no doubt as to the difference existing in the structure of the tentacles in different genera of the family; as we have seen in Sarsia the circular chymiferous tube radiating into the four marginal tentacles, whilst in Hippocrene there is no such communication between the two organs.

The nervous cord (Plate I. Fig. 2, 3, 4; Plate III. Fig. 1, 2, 3, 4, 5, 7, 8, 9), which extends from bud to bud, with a ganglion at the base of each bud, is not the only part of the nervous system which I have been able to trace in this animal; and though the other portions of this system differ widely from this main cord, I entertain scarcely a doubt as to their real nature. On examining minutely the walls of the vertical tubes, which are so uniform in their homogeneous structure, it is easy to discover on their inner surface one or two threads (Plate III. Fig. 5), following along the whole length of these tubes. Below the curve where the tubes bend to form the loop which is connected with the central digestive cavity, these threads combine into a plexus (Plate III. Fig. 6) of intricate fibres, from each of which arises another thread extending horizontally from one plexus to another (Plate III. Fig. 5), so that there is a circle of such threads all round the upper part of the chymiferous system, or below the centre of the gelatinous disk. This circular thread, considered in itself, may therefore be viewed as a ring encircling the upper part of the chymiferous system, forming a plexus of similar threads under the curve of each radiating tube, from which identical threads may be traced downwards to the sensitive bulbs, in which they also merge. From the middle of each upper horizontal thread, there arises a vertical thread extending downwards, and following the main course of the large inner vertical bundles of muscles.

I am not fully satisfied of the real nature of this apparatus, on account of the great difference there is between these threads and the sensitive cord of the lower margin.

Far from consisting exclusively of short ovate cells connected together in several rows, we have here very thin threads, in which the cellular appearance is almost entirely gone, excepting where they combine to form a plexus, in which some of the threads have the appearance of long caudate cells. For a time I mistook these threads for muscular fibres; but they differ from muscular fibres quite as much as they do from the main nervous cord. They are somewhat peculiar in their appearance in every respect, and from their connection with the chymiferous tubes, from the disposition of their plexuses and the circular connection between them, and from their connection with the sensitive bulbs below, I have been led to consider them as parts of the nervous system. What corroborates this view is, that I have never noticed any indication of contractions in these fibres, although contractions are so readily observed in the real muscular cells; while, on the other hand, the plexuses which they form remind us rather of the arrangement of nervous fibres than that of muscular fibres; so that, though some doubt may be entertained as to the real nature of this system, it seems more natural to consider the whole of these threads as nerves than as any thing else. I am the more disposed to consider them so, since, in Sarsia, a similar system has been traced having similar connection with the surrounding parts, bearing, perhaps, still less resemblance to the muscular system; and though I have spoken of it with some hesitation, I trust that further investigations will confirm this view. The fact that some threads arising from the plexuses below the arch of the chymiferous tubes descend along the sides of the main central digestive cavity, might be further considered as another indication of the nature of this apparatus; for muscular fibres could perform no function in connection with this cavity; the less so, as the whole cavity, as such, is capable of extensive contractions and dilatations by means of its own tissue, as described above. Finally, there is one circumstance agreeing with this view, which ought not to be overlooked, namely, that isolated threads arise from the middle of the threads extending from one plexus to another, and descend vertically from this circle along the main vertical inner bundles of muscles.

Thus the analogy between this apparatus and what has been observed in Sarsia is so complete, as to afford another argument in favor of the view I have taken of it in this animal. If this view is correct, the nervous system of Hippocrene, like that of Sarsia, would consist, 1st, of a main circular cord round the lower margin, following the circular chymiferous tube; 2d, of vertical threads following the vertical chymiferous tubes; and 3d, of a circle above, around the central digestive cavity, but at some distance from it. The main distinctive peculiarity between this system and that of Sarsia would consist in the plexuses below the arches of the radiating tube, which have not been noticed in Sarsia. This sensitive system is observed to be in so close connection with the sensitive buds, as to justify the opinion that the dark-colored specks at the base of the tentacles are connected with the faculty which these animals distinctly possess of distinguishing light from darkness, although the connection with the nervous ganglia may not be such as to allow the formation of a distinct visual image.

The connection of the tentacles and eye-specks is closer in this animal than it is in any other of the naked-eyed Medusæ, with the exception, perhaps, of Sarsia and Slabberia, in which the eye-specks rest also upon the base of the tentacles. In Sarsia, however, the eye-speck is on the upper side of the tentacles, and the whole bud is less connected with them than it is in Hippocrene. Moreover, the tentacles being hollow in Sarsia, and in direct communication with the chymiferous tube, they must at once appear in closer connection with the chymiferous system than with the eye-specks; while in Hippocrene the tentacles, being excluded from any connection with the chymiferous system, appear connected only with the sensitive buds; so that the relations of the apparatus are considerably modified in the two types; and the fact that in Hippocrene so many eye-specks are combined in so close a manner into one and the same bud, with as many tentacles, introduces here a relation of the tentacles which is peculiar, and doubtless has reference also to their peculiar structure, in which nettling cells are so few, if, indeed, there be any proper nettling cells.

The name *superciliaris*, applied to this species, is derived from this connection of the tentacles with the eye-specks. Although this peculiarity is generic, it may be said that, in *Bougainvillia nigritella* of Forbes, there is but one tentacle to each bud, if the specimens observed were at all perfect; that there are fewer in *Bougainvillia Britannica* than in the North American species; and that in the original species, as described by Lesson, there are also fewer; so that the name of *Hippocrene superciliaris* appears quite appropriate for this species.

The above details, respecting the sensitive apparatus of so small an animal as this, will further justify the general remark already made, that there is here a much closer connection between the structure and form than is observed in any other type of the animal kingdom. Indeed, the bulbs at the four corners of the lower margin, with their movable appendages, form so prominent a feature in the appearance of these little animals, that at first sight nothing in them strikes the oye but those four dark prominences, with the main central digestive cavity; and whenever an attempt at a minute description is made, even if it be restricted to external appearances of form and color, it must include particulars which have as much reference to the anatomical structure of these animals as to their external appearance.

As in all the other Medusæ, in order to study well the arrangement of the muscular tissue, and to be able to trace its numerous bundles in all their details, it is necessary to watch specimens in a state of great contraction, when they are about dying, or shortly after death, and even during the process of decomposition. The powerful contractile bundles on the inner surface of the gelatinous disk, to which the most powerful action during life must be ascribed, are best seen in those specimens which are rapidly dying under spasmodic contractions; — while the superficial layers outside of the gelatinous disk are even better seen when the animal is already decomposing, and the tessellated epithelium, which covers the whole surface, is either decaying or separating from the body. The cells of the lower partition are easily observed in fresh specimens during life, probably owing to the circumstance that this partition is much thinner, and consists of finer organic elements.

When examined under a powerful microscope, the superficial epithelium (Plate II. Fig. 5, 6) is found to differ in different parts of the body, and it is advisable to be familiar with it before attempting to investigate the muscular apparatus. All over the bell-shaped part of the disk, this epithelium consists of irregular polygonal cells, the outlines of which are so faint that they are hardly ever distinguished; but their existence can easily be inferred from the peculiar arrangement of their granular contents, which form a sort of mosaic (Plate II. Fig. 5), circumscribed within angular outlines, in the interior of which larger nuclei of irregular form are noticed, sometimes placed in the centre of these areolæ, sometimes nearer their outlines. The forms of these nuclei vary also, being either ovate or circular, or elongated, straight or curved, or even angular. As in the fresh state these parts are too transparent to be well distinguishable, and they only become visible in a rather advanced state of decomposition, I am not perfectly sure that this irregularity of form is entirely natural, and that the nuclei, in particular, have so diversified an appearance as is observed in the shreds which are so easily detached from the surface of the gelatinous mass during the decomposition of the body. But so much is certain, that such a ragged appearance, and this greater irregularity of the nuclei, (Plate II. Fig. 6,) are particularly observed upon the outer surface of the lower margin, where the vertical portion of the disk is turning over between the colored buds to form the transparent lower partition; and it may be that the character assigned by Mertens to his species, of having a kind of villosity around the margin, is owing to a greater irregularity of the epidermal cells in that species than in the one which I have examined. Upon the sides, however, and above the disk, as well as upon the inner surface of the main cavity, I have only noticed those more regular polygonal and flat epithelial cells, the greater number of which contain only minute granules, and occasionally among them a few larger nuclei, the whole forming a very thin film over the entire surface of the body. The villosities mentioned as characteristic of many Medusæ may be owing to a similar epithelium differing in the form of its cells; but, as I shall have an opportunity of alluding to these cells again when speaking of the Pleurobrachia of the American shores, I will not dwell longer upon this subject now, nor make any allusion to the descriptions given by Ehrenberg of the structure of the tissues of Medusæ, as he observed it in the genus Aurelia; since his statements will better be discussed when describing the species of that family which occur in this vicinity, which will be done in the third part of this paper. The superficial bundles of contractile cells,* which are covered by this epithelium, form a remarkable network all over the external surface. They are arranged in two particular directions, the main bundles (Plate III. Fig. 7, 8, *a*, *a*; Fig. 2, *d*, *d*; Fig. 1, *e*, *f*) being vertical, and alternating with the chymiferous tubes; there being, also, circular bundles (Plate III. Fig. 1, *a*, *a*, *c*, *c*, *h*, *h*; Fig. 2, *a*, *a*) upon the surface, to which the vertical ones are attached, or with which they are at least connected. These transverse or circular fibres form first a circle (Fig. 1 and 2, *a*, *a*) above the curves of the chymiferous tubes, and another (Fig. 1, *c*, *c*) somewhat below, though this is less regular than the upper one. The upper crown or circle of muscular fibres appears like a loose net (Fig. 1, *b*, *b*) hanging over the gelatinous disk, and its position seems to favor the action of the vertical bundles, which are so connected with the circular fibres as probably to derive support in their action from their simultaneous contraction; for, from this upper ring there are muscular fibres rising upwards and arched over (*b*, *b*) towards the centre: so that, when well preserved, the muscular apparatus of this upper region of the spherical body appears as if covered with arches of muscular bundles converging upward, and resting upon a circular ring below their base. The network of arches upon the most prominent part of the summit of the disk does not exist at all in the specimen of Plate III. Fig. 2; but the circle of fibres, *a*, *a*, corresponding to that of Fig. 1, *a*, *a*, is stronger in its development, and when contracting seems to have been more deeply impressed into the gelatinous disk, than the more extensive net of muscular fibres of the specimen represented in Fig. 1. Fibres extending downwards (*d*, *d*) from this upper crown, in connection with similar transverse fibres below, form the second circle (Fig. 1, *c*, *c*), which, in its complete state, constitutes, as it were, a lower series of arches, upon which the upper rest, or to which they are suspended. From this double row of large muscular meshes arise the vertical bundles (Fig. 1, *e*; Fig. 2, *d*, *d*), which extend to the lower margin of the disk, meeting it in the middle (Fig. 1, *f*), between two sensitive buds. There are, therefore, four of these more prominent external bundles of contractile fibres;

* The whole system of contractile cells, in whatever position they occur in the body, is figured upon Plate III., in blue outlines.

but, in addition to them, smaller bundles arise, which follow, in a rather less regular arrangement (Fig. 1, *h*, *h*; Fig. 2, *e*, *e*, *e*), the direction of the vertical tubes, and terminate (Fig. 1, *g*, *g*) above the sensitive buds.

The general position of the two specimens, Fig. 1. and Fig. 2, must explain the great difference in their appearance. In Fig. 1, which is an absolute profile, we face the interval between two vertical chymiferous tubes; and the two other tubes, being precisely in the same position on the opposite side of the body, are not introduced at all in the drawing. In Fig. 2, on the contrary, which is slightly inclined upon its base, in order to show the lower partition, and to bring out the upper crown of fibres as a continuous ring, we face, in the middle, one of the chymiferous tubes, and have another opposite to it, also in the middle, on the other side of the body; and at right angles with this, two other tubes, one to the right and the other to the left; and the spaces between two vertical tubes appear everywhere foreshortened. Fig. 1 of Plate III. is nearly in the same position as Fig. 1, Plate I., with this difference, that, being absolutely in profile, the other pair of vertical tubes is not seen at all. The corresponding parts of Fig. 2 would form angles of forty-five degrees with those of Fig. 1, if projected upon the same plane.

On investigating closely the arrangement of these fibres, it is found that they do not extend in a straight course from the upper part of the sphere to its lower margin, but diverge into the arched bundles above, and in their lower course give off along their whole track similar diverging fibres. So that, properly speaking, there are four main pennate muscular bundles upon the surface, alternating with the course of the chymiferous tubes, and four smaller ones following the tubes. With the arches rising from these vertical bundles, an intimate connection is established by the more mesh-like arrangement of the upper network of muscular fibres. In their course, all these fibres remain chiefly superficial. Some of them, however, especially those of the four main vertical bundles, penetrate more or less into the gelatinous mass, though they seem nowhere to meet the corresponding bundles, which, from the inner surface, penetrate likewise into the gelatinous disk, excepting, perhaps, in the lower portion of the disk near its margin, where the gelatinous mass is much thinner, and where the superficial external bundles seem to intermingle with the deeper bundles of the inner surface.

The action of this muscular apparatus is quite obvious, both from the arrangement of the bundles, and from direct observation. The upper network of fibres contracts the upper part of the disk, while the vertical bundles shorten it, as they are strongest below, and, when combined in action with the inner bundles, they turn the lower margin inward. In this contraction, and especially when the vertical bundles are most shortened, the four marginal buds are bent inward and brought nearer together. This is particularly the case when the lower parts of the vertical bundles of the inner and outer surface of the gelatinous disk act simultaneously; but when the outer ones alone are contracted, and especially the small bundles (Plate III. Fig. 2, *e*, *e*, *e*) above the buds are in activity, they expand the sphere again, and turn the buds outward and upward.

Though, perhaps, less complicated in their course, the inner vertical muscular bundles (Plate III. Fig. 3, 4, 7, 8, 9, *d*, *d*, *e*, *e*, *f*, *f*) which line the inner surface of the gelatinous disk are still more difficult to trace, and their action is less easily ascertained. There are four main bundles (*d*, *d*), the position of which is easily recognized. They arise from the lower surface of the gelatinous disk, above the digestive cavity, between the radiating tubes (Plate III. Fig. 9), and follow a vertical course, their fibres remaining closer together than those of the external layer; though here, also, the contractile cells diverge upwards and downwards in such a manner as to give each of the bundles somewhat the appearance of a pennate muscle. These bundles (Plate III. Fig. 3, 4, *d*, *d*) terminate below the margin midway between the sensitive buds. Their fibres penetrate more deeply into the gelatinous mass, especially below, where they meet the superficial bundles, and intermingle with them (Plate III. Fig. 8, *d*, *a*, *d*, *a*, *d*, *a*), under acute angles, *a* being the superficial, and *d* the inner vertical bundles. Of course, seen in profile (Fig. 3, 4), these bundles follow the curve of the gelatinous disk, which is the same as that so plainly shown by the chymiferous tubes. When seen from above (Fig. 7, 9), it might easily appear as if there were several bundles of muscles placed one above the other; for in this position, the arch which the bundle forms from the centre towards the lower margin is so foreshortened, that its upper portion is seen separately from the lateral portion; and as this is straighter, the appearance is as if a stronger muscle were placed outside of the feebler one, which seems to be nearer the digestive cavity. But a vertical view (Fig. 3, 4) will leave no doubt about the continuity of these muscles, and easily show that the appearance noticed from above is that which a vertical pennate arch would present if it were drawn so that both the arched and the vertical part could be seen projected upon the same plane (Fig. 7, *d*). Then the arched part passing into the vertical stem would be foreshortened so as to appear very thin, and the long vertical branch itself would appear very strong, from the many branching fibres thus accumulated upon each other in the vertical view. In Fig. 7, *d*, where these main bundles are thus foreshortened, they appear like anchors, owing to the particular focus under which they were drawn; when, in addition to the complications already mentioned, the pennate arrangement of the fibres appeared most prominent, and formed, as it were, the two curved arms of the anchor.

Alternating with these main bundles, there are eight others (Plate III. Fig. 3, 4, 7, 8, 9, *e*, *e*, *f*, *f*), which, however, are much less powerful, and are placed half-way between the main bundles and the chymiferous tubes on both sides. These bundles follow the same course as the four others, and present the same relative disposition of their fibres, but in such a reduced scale as not to be always apparent, and hardly ever to appear as continuous vertical pillars of contractile fibres. Their existence, however, cannot be doubted for a moment in certain states of contraction of the inner surface, when the muscular vertical bundles are shortened in such a manner as to form with their pennate threads undulating lines curved in opposite directions, which, in a view from above or below, intersect each other completely. Such a view is given in Plate III. Fig. 7, 8, 9, where the main bundles, with their lateral fibrillæ, are curved inwards, and the eight secondary bundles outwards, meeting, in this case, similar curves formed by the strong bundles. The greatest difficulty is experienced in forming correct ideas of all these undulating lines intersecting each other, unless one has traced them in all possible degrees of contraction. When the body is slightly contracted, and its circular form is still preserved, as in Plate I. Fig. 3, 4, the intersecting lines are only those of the four main bundles marked out upon the outlines of the gelatinous mass. But as the contraction increases, as seen in Plate III. Fig. 8, the undulating lines of the outer surface are seen to correspond to the inner ones, and the eight secondary bundles coming into play, instead of four arched lines there are now twelve, intersecting each other; and in Plate III. Fig. 7, the contraction being most powerful, each of these curves forms a narrow arch, and all these arches intersect each other in the same way, to form now an eight-rayed star instead of a more or less quadrangular figure, the chymiferous tubes alternating with the four main muscles to form the curves bent inwards, and the eight muscular secondary bundles arched outside to form the eight prominent angles of the figure, the undulations of the external surface corresponding, even in that state, to those of the inner surface. The correspondence of the external and the internal vertical muscles is remarkably well shown in Plate III. Fig. 7, 8, where *a*, the main external vertical bundles, correspond to *d*, the main internal vertical bundles, and *e* and *f*, the secondary internal vertical bundles, correspond to less regular secondary external bundles, *b*, *b*.

The third chief layer of contractile cells (Plate III. Fig. 3, 4, *i*, *i*) lines the main cavity of the body, and presents a circular arrangement, so that, in its chief disposition, this system crosses the vertical bundles everywhere at right angles. The existence of a continuous muscular coat over the whole inner surface of the lower side of the disk would hardly be suspected, unless upon the closest examination, and a careful selection of suitable specimens. But whenever its constituent parts are in such a state of contraction as to render them visible at all, they are very distinct. This layer lines the whole cavity between the main digestive sac and the lower partition, covering the four radiating chymiferous tubes, and being itself covered by a very thin epithelium, not always easily seen upon every point; the existence of which, however, is frequently revealed by the polygonal flat cells which are detached from its surface. This muscular layer is not a simple coat lining uniformly the whole cavity of the body. On the contrary, it consists properly of four sets of transverse bundles, extending from one chymiferous tube to another; so that it may be said that there are four walls of horizontal contractile fibres, beginning above the main digestive cavity, curving over between the arches of the chymiferous tubes, then extending downwards to the horizontal circular tube, and meeting for their whole length upon the inner surface of the vertical tubes. Seen from above, these circular fibres appear like a ring encircling the upper part of the central digestive cavity. This ring has a double outline, as may be seen in Fig. 7, *b*, *c*; Fig. 9, *b*, *c*; and Fig. 4, *b*, *c*. Whether this double contour, however, arises from the relation between the circular muscles and the chymiferous tubes, or whether there is a double layer of muscular fibres in the upper part of the disk, or whether the double outline arises from the curve of that part of the inner surface, bringing in each particular position certain fibres more prominently into view, I have not been able to ascertain. Though in the main horizontal, or transverse, these fibres are more or less arched upwards and downwards, or outwards. They are arched upwards above between the arches of the chymiferous tubes. They are arched outwards about the middle of the bell-shaped disk, and they are somewhat arched downwards nearer to the lower margin. The fact of these circular horizontal fibres meeting upon the inner surface of the vertical tubes is important, inasmuch as it is one argument more against the supposition, that the vertical threads which accompany the vertical tubes in their regular course, and which I have ascribed to the nervous system, are of a muscular nature. Moreover, it is easy to see that, while the former are either in a contracted or relaxed state, the latter always present the same appearance.

The natural function of these circular fibres is to reduce the capacity of the central cavity, and hence, when assisting the vertical fibres, to contribute to locomotion. But they may also be subservient to the process of circulation, by the traction they exert upon the radiating tubes. A slight contraction may also contribute to renew the water in contact with that inner surface. The fact, that they line so uniformly the whole central cavity of the body, would lead to such a supposition. Indeed, Medusæ whose body is so little active and almost closed as that of Hippocrene need some special means besides the locomotive movements to maintain a regular exchange between the water within and the water without the cavity. I have so often observed the lower of these fibres contracting more powerfully than the upper ones, that I hardly entertain a doubt with respect to their coöperation in the locomotive process. But, had not this system a particular *function*, I hardly see why it should be so well developed in the upper part of the inner cavity, which is hardly liable to great changes arising from muscular action. The fact that these horizontal or circular fibres line the arched cavity gives to the fibres themselves, when seen in different positions, such various aspects, that here again it is very difficult to form correct views of the whole system; especially so, as very often the curves of the horizontal fibres coincide with the curves of the fibres diverging from the pennate vertical muscular bundles, in such a manner as to cover each other in the perspective, or to be easily mistaken one for the other. And, in such views, the horizontal circular fibres contribute to strengthen the appearance of the intersecting undulating lines formed by the vertical bundles already described, especially when seen from above (Plate III. Fig. 9, *i*). But in profile views, the fibres belonging to the circular system are readily distinguished from the fibres belonging to the vertical bundles, even when they assume an arched appearance, by the circumstance that the former are attached to the chymiferous tubes, as seen in Fig. 3 and 4, while the latter alternate with these tubes. About the chymiferous tubes, there are, however, more or less distinct threads, especially upon the inner surface, which seem to intersect the horizontal circular system, and nevertheless neither to belong to it nor to the vertical muscles. They rise (Fig. 3, 4, *g*, *g*) chiefly from the middle of the height of the main cavity, and diverge towards the main vertical muscles, following, however, the form of the main cavity, upon the inner surface of which they are appressed, and intersecting under various angles both transverse and vertical fibres. But for these fibres, I should not have the slightest doubt respecting the real nature of those other fibres which I have ascribed to the nervous system; and had I noticed a plexus-like crossing of these fibres with each other, I should have given up the idea that the meshes of fibres under the chymiferous arches are sensitive plexuses. But here the oblique fibres intersect fibres of other systems, and do not intersect each other, as in the plexuses described above.

In addition to the difficulties depending upon the nature of the subject itself, which we experience in tracing these muscular bundles, there is another difficulty, arising from the position in which we trace them. There being four radiating tubes, the whole animal assumes a very different appearance, according to the position in which it is viewed. When we look at it in such a position that two tubes are placed upon one side and two upon the other, as in Plates I. and III. Fig. 1, we face the flat side of a broad surface stretching between the two tubes nearest to us in the *profile*. But if we place the animal in such a position as to have right and left a single tube, and one upon the middle line in front covering another behind, we at once place the plane between the tubes in an oblique position, and every thing in a different light. And these two positions, in which it is, after all, easiest to study the parts of the animal, may be still further complicated by introducing intermediate positions; such, for instance, as that represented in Plate III. Fig. 5; and the difficulties are beyond the patience of the observer, if, in addition to these numerous front positions, the difficulties of oblique positions are introduced, in which partial views from above are combined with partial profiles. I have spent weeks in attempting to make myself familiar with these different views, and if I were not conscious of having overcome most of the difficulties connected with the investigation, I should by no means be so positive about the direction of the fibres of the muscular system in the different layers described above.

The region about the upper part of the digestive cavity presents such a complication of different parts brought in connection with each other, that it is very difficult to form correct ideas of them, and still more to appreciate their forms and connections, when seen either from above or in profile. There is, especially, one point which puzzled me for a long time, — the fact that, in the upper part of the arches of the vertical tubes, all the outlines seem double. This is partly owing to the circumstance that the mere form of the main cavity of the body gives rise, under different intersections of light, to the formation of outlines which have no real existence, and that these outlines, seen across the gelatinous mass from the two sides, are reflected upon each other. But after this difficulty has been overcome, and we see the structures in their true simple character, there is still a difficult point in defining the outlines of the upper transverse muscular bundles stretching between the arches of the chymiferous tubes, and in distinguishing them from the circular nervous thread, which connects the nervous plexuses under the arches of the chymiferous tubes; for here, again, the muscular fibres run so nearly in the same direction as the nervous thread, that, but for the contractility of the one and the steadiness of the other, they would be easily mistaken; and I am not fully sure that, even after alluding to this difficulty, they will always be correctly seen, especially when examined from above. A comparison of Fig. 4 and 5 of Plate III., in which the nervous system (Fig. 5) is represented in a position of the animal almost identical with that in which we see the system of circular muscular fibres, Fig. 4, will at once give an idea of the amount of difficulty there must be in identifying these various parts, especially when it is remembered, that both the nervous and muscular systems have to be studied through the thickness of the gelatinous disk. Seen in absolute profile, the difference is more obvious, for here the muscular bundles are so arched as to contrast with the nervous fibres stretching across the same space.

There is another point which requires particular attention. Owing to the thickness of the chymiferous tubes, the transverse muscular coat of the inner surface is somewhat separated from the inner surface of the gelatinous disk near the tubes themselves, and these spaces left between the disk and the layer of muscles on the sides of the chymiferous tubes give rise to a double contour in the uppermost part of the arch, which, in addition to the difficulty already mentioned, is likely to create misapprehension in estimating the appearances presented by the parts meeting about the centre of the disk under the gelatinous mass.* Indeed, seen from above, it would seem as if there were a distinct circle of peculiar organs, or rather of peculiar tissue, the periphery of which would inclose the space to which the prominent corners of the digestive cavity reach, as seen in Plate III. Fig. 7 and 9, and also Plate I. Fig. 3. The fallacy of this outline is further increased by the appearance of the four main bundles of vertical muscles, which arise, as it were, from those of the circle, (Plate III. Fig. 9,) and stretch downwards. The outline of these circular fibres is sometimes made very prominent when the opening of the lower partition is reduced by contraction, as in Fig. 7. Both circles, however, are more distinct and farther apart when the outline of the lower partition is in a state of relaxation, as in Fig. 9. This outer circle, as seen from above, is a real outline. It is the free margin of the lower partition, *k*, which is as definite as the outline of the lower circular tube, *o*, or the nervous cord, *m*, which in such views are all brought together in focus; but the middle upper circle has no more reality than the undulating lines *d*, *e*, *f*, seen outside of the chymiferous tubes, in Fig. 7, 8, 9, and 4, — which are only the foreshortened outlines of the undulations produced by the contraction of the muscular system, — with this difference, that the upper circle is formed both by the muscular coating, and by the influence which the prominent gelatinous knob in the centre has in causing an outline to appear round its base, where it bends over into the arch of the sides. But the double outline between the muscular coating and the arches of the chymiferous tube is hardly ever noticed from above; neither is it noticed in the complete profile; but it is constantly and distinctly seen in a three-quarter view (Plate III. Fig. 2, and also Fig. 4); and I must confess that I never met with more perplexing difficulties than those I experienced in satisfying myself of the real nature of what so clearly seemed a structure, which always vanished under certain influences of light, while it was so plain under others.

The fourth muscular system is extended between the four sensitive bulbs within the lower margin. Plate I. Fig. 2, 3, and also Plate III. Fig. 9, *k*, and Fig. 2, *f*, *f*, give an excellent view of it, in its general outline, though no structure could be drawn with

* Upon this particular point, compare also another remark already introduced above, when describing the circular fibres.

this magnifying power. But from those figures, (and, if the attention is once called to it, Fig. 1 and 4 of Plate I. will show the same,) it may be noticed that there is a partition stretching inwards from the lower margin, terminating with a free edge, through which a broad and free passage is left between the main cavity of the body and the surrounding medium. This partition, which thus almost closes the main digestive cavity and its contents from direct communication with the surrounding medium, is highly movable and contractile, and indeed consists chiefly of muscular fibres, covered with a very thin epithelium. It is not a mere prolongation of the lower edge of the disk, nor are its contractile fibres a part of the inner circular system of bundles; for it arises from the inner margin of the circular chymiferous tube, and the main nervous cord. It is not gelatinous, as the disk, and though very clear cells surround and protect the chymiferous tubes and the nervous cord of the lower margin, and thicken its walls, nothing of the clear jelly-like substance is seen within the horizontal partition. It is made up, outside, of epithelial cells, and within chiefly of a thick layer of circular muscular fibres, with which alternate some few radiating fibres, which cross the former at right angles, and are more numerous about the eye-specks. In Plate II. Fig. 14, *g*, *g*, a portion of this partition near the sensitive bundle is represented, with its circular and radiating fibres. In Plate III. Fig. 12, the linear arrangement of the circular fibres is shown, without their natural connection with the radiating fibres. And in Fig. 14 of the same plate, the radiating fibres, *d*, alone are represented, to show how they converge towards the main bulb. In Fig. 15, again, a portion of the lower margin is figured, to show the connection between the sensitive cord and the circular chymiferous tube, *b*, *c*, the thick wall of the body, *d*, and the horizontal partition, *a*. The fragment here represented is seen from outside, laid flat. The natural connection of all these parts may be better ascertained from Plate II. Fig. 17, where *d*, *d*, represent the vertical tubes above the bulbs; *a*, *a*, the circular tube; *b*, *b*, the nervous cord; *c*, *c*, the horizontal partition; *f*, fibres of the main vertical inner bundles; and *e*, the outline of the external surface of the wall of the body. The arrangement of the fibres of the partition is very much the same as that of the contractile fibres of the iris; and its operation also the same, inasmuch as this main orifice is alternately widely opened or closely shut.

These muscular fibres cannot be referred to the same system as that which lines the main cavity, for they are continuous all round the partition, and not attached in any point of their circuit to other organs, but support each other in their connection. The contraction of these muscular fibres, however, may be combined in such a manner with the contractions of the other muscular bundles, as either to protrude the partition between the sensitive bundles outwards in the shape of a beak, or to retract it into the shape of a funnel. I suppose these very great changes in its form (for it is generally stretched horizontally) are brought about, in a great measure, by the action of the muscular fibres which arise from the chymiferous tubes, and run obliquely downwards. (Plate III. Fig. 3, *g g*, Fig. 4, *g*, *g*, *h*.)

The appearance of the muscular tissue in this animal, as studied under high magnifying powers, varies somewhat in different parts of the body. Wherever the tissue can most easily be traced in its intimate structure, scarcely a doubt can be left that the muscular fibres are elongated cells. Indeed, in the horizontal partition, it is as plain as possible. The whole tissue appears like layers of elongated, or rather caudate cells, with one end blunter than the other; and the nucleus near the larger end now and then contains a nucleolus. These cells are in such juxtaposition as their heterogeneous form requires to fill the whole space, the blunt end being sometimes in one direction, and sometimes in the opposite direction, and the attenuated part of the cells packed more or less closely together, so as to leave no empty space between, as is seen in Plate III. Fig. 11, or in Fig. 10, where they are more fully metamorphosed. These latter cells appear almost entirely thread-like, though the nuclei are still preserved. In the large vertical bundles, however, the approach to ordinary muscular fibres is nearest, inasmuch as few nuclei remain between the threads. But one circumstance distinguishes such muscles completely from any of the muscular structures of higher animals: there is nowhere any indication of transverse striæ upon the fibres; there are no sarcous elements, nothing like that reticulated structure of true muscles which has been observed in the higher animals. The condition of the voluntary contractile system of Medusæ comes nearest to that of the unstriated muscles of higher animals. Indeed the aspect of the true voluntary muscles of Hippocrene almost reminds us of the figures of unstriated muscle given by Kölliker.

IDEAL SECTIONS.

Though the figures to which I am about to refer cannot claim the merit of extreme precision, they will at least contribute somewhat to an understanding of the results to which I have arrived respecting the structure of this animal. I have therefore thought it useful to introduce them, in order that all the parts, which I have above described in their natural relations, may be thus represented more definitely than they are really seen in nature.

Plate VIII. Fig. 1, gives merely an outline of the gelatinous disk in a vertical section. It will be noticed here, that its inner lower surface, instead of being simply arched, has a central rounded prominence, *a*; that the thickest part of the vault, *b*, is above the main cavity; and that the lateral walls, *c*, gradually taper downward into a narrow edge. The difference between the form of Hippocrene and that of Sarsia will be particularly obvious, when this figure is contrasted with Fig. 4, which represents the disk of Sarsia in a similar section; where it is seen, that the lower surface of the vault, *a*, is uniformly arched, without a central projection; that the thicker portion of the vault, *b*, is much thinner than in Hippocrene; and that the lateral walls, *c*, are comparatively higher

Fig. 2, 3, present two views in vertical section; in one of which, Fig. 2, the section passes through the main cavity, across its flat walls, in such a manner as to leave two tubes in each half wholly untouched, which thus follow, in their natural position, the inner surface of the main cavity; and these tubes are represented in the same position in which they also appear in the transverse sections, Fig. 7 and 8. In the other view, as given in Fig. 3, the section passes through the main cavity, in such a manner as to cut through the angles of that cavity, and pass through two opposite tubes, which appear on the sides of the figure. One of the two other tubes, which are placed at right angles with the former, is seen in its natural position, untouched, rising behind the middle of the main digestive cavity, and descending along the wall below the mouth. In both figures, the main digestive cavity is cut into halves; but in Fig. 2 it appears narrower, as the cut passes through its shorter diameter, without cutting into the projecting angle, and only the openings leading to the vertical tubes are seen, as the tubes themselves rest against the walls, which have remained entire; while in Fig. 3, the section passing through the tubes themselves, their cavity is laid open in direct continuity with the main digestive sac, the greatest width of which is here laid open. The inner vertical muscular bundles (Fig. 2, *a*), as well as the outer vertical ones (Fig. 2, *b*), and the transverse bundles (Fig. 3, *c*), as well as the horizontal partition (*k*, *k*, *k*, *k*), are distinctly shown, the relative size of the fibres being, however, exaggerated, in order to bring more fully into view the different systems. The nervous system is represented by simple dots (Fig. 2); *d*, *d*, being the transverse section of the main circular cord, and *e*, *e*, the transverse section of the upper circular thread. In Fig. 3, however, the vertical nervous threads, *f*, *f*, and the plexus, *g*, *g*, under the arch of the vertical chymiferous tubes, may be followed along their whole course. The eye-specks, with the tentacles, are also introduced (Fig. 3, *h*, *h*); but the tentacles are cut short near the base in order not to complicate the figure too much. The circular chymiferous tubes (*i*, *i*, *i*, *i*) appear in the two figures in a transverse section, being in Fig. 3 somewhat wider at the base of the eye-speck. Fig. 5 and 6 represent precisely the same parts in Sarsia, with corresponding letters, so that a comparison of the figures will best exemplify the difference between the two genera.

Fig. 7 represents a transverse section just above the main digestive cavity; and Fig. 8 represents another transverse section just above the eye-specks, where the transverse diameter of the body is smallest; the dotted circle outside indicating the greatest periphery of the animal. In Fig. 8, the vertical tubes are intersected in the lower part of their vertical branches; but in Fig. 7, through both the ascending and the descending branch, just above the main digestive cavity. In this way, the true relations between all parts are easily appreciated.

In Fig. 7 we see the circular muscular fibres (*a*) and all the vertical bundles cut transversely, the external (*b*) as well as the internal (*c*), the main bundles as well as the secondary ones.

In Fig. 8, instead of the main digestive cavity, we have in the centre the lower partition (*a*), the main nervous cord (*b*), the circular chymiferous tube (*c*), and the four bulbs (*d*), fully displayed. But the sections of the vertical muscular bundles (*e*, *e*) are much smaller, and the lateral walls are much thinner.

Fig. 9 and 10 correspond to Fig. 7 and 8, respectively; showing the same parts under the corresponding letters, with this difference, however, that, the upper arch of the chymiferous tube being uniform in Sarsia, the section which passes through the main digestive cavity lays open, for a considerable distance, the inner cavity of the tubes themselves, as well as that of the digestive sac; if it had been made a little lower, the whole central cavity would have been removed, and only one section across the vertical tubes would have been shown, and not two, as in Hippocrene, the tubes forming no cross in their upper region. Again, in Fig. 10, when contrasted with Fig. 8, we see, in the centre, a transverse section of the proboscis, as this hangs almost constantly lower down than the lower outline of the main mass of the body; but otherwise, all parts are precisely identical.

The alternate generation of Hippocrene has not yet been traced directly, so that I am unable to say whether this species originates from a Hydroid Polyp, similar to Corynæ, or from one of the new genera described by Sars; or whether the suggestion which I made in my Lectures on Embryology, that they arise from Tubularia, is a correct view of the case. From the greater number of tentacles in Hippocrene, from their more prominent connection with the margin of the bell-shaped disk, and from the numerous fringes around the opening of the mouth, I was led to suppose that the Tubulariæ are really the polypidoms from which Hippocrenæ are produced. I feel still more inclined to consider them so, as specimens of Hippocrene are scarce, when those of Tubularia are very abundant; and for the reason that the reverse is the fact with Sarsia and Coryna, I should say that we are justified in considering them as sustaining that relation to each other. For those animals which pass through alternate generations in the course of their development will prosper either in one or the other state; and the one which is the most prominent feature in their existence brings, as a natural consequence, the less frequent occurrence of the other state; just as those caterpillars which live long in the caterpillar state are more frequently met with than the moth which they produce, the duration of whose life is short; and *vice versâ*, the butterflies, which live nearly throughout the year, and spend a few weeks only in the caterpillar state, are more often seen in a perfect condition, while the caterpillars are of rare occurrence.

Another difficulty would seem to be more serious, namely, that there are at least two species of Tubularia, very different from each other, found on these shores; while only one Hippocrene has as yet been noticed. I am well aware that more than two species of Tubularia have been described, but I should not be in the least surprised, if all the branching and simple varieties were mere forms of two distinct types, one of which has a large crown, and the other a small one, — one a prominent inner tube, and the other a shorter one. The fact that the proboscis in Tubularia is fringed around its opening is greatly in favor of its being the alternate generation of Hippocrene, in which the mouth is also adorned with bunches of fringed or branched tentacles. But the difficulty of more species would be unanswerable, if we could be positive that we know all the species of Medusæ occurring along these shores. That this, however, is by no means the case, I ascertained during the last summer, when I found (in localities where the two types of Tubularia occur simultaneously) no less than four species of Medusæ belonging to four different genera, which had never been noticed before on the coasts of Massachusetts;* and one of these new species is closely allied to Hippocrene; though, from the peculiarities in its tentacles and eye-specks, I am inclined to consider it a peculiar genus, of which I shall say a few words at the close.

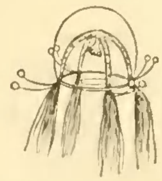
I have had some hope of raising the polypidom type of Hippocrene from eggs of this species, but have been unsuccessful in this respect, though several specimens I had preserved in glass jars have laid their eggs in captivity. But these eggs are so minute, that with all possible care, and all attention bestowed upon them, I have been unable to preserve them so as to watch their growth. The eggs are so minute that it requires a certain magnifying power even to see them, and to watch them in the water after they have been scattered about is almost impossible, as the isolated eggs completely escape the power of the naked eye.

* For the opportunity of observing so many new marine animals, I am indebted to the liberality of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, who has repeatedly allowed me to avail myself of the surveying vessels under the command of Lieutenant Charles H. Davis, for the purpose of scientific investigations. I cannot allow this opportunity to pass, without acknowledging publicly my gratitude for this liberality, and returning my most sincere thanks to Lieutenant Davis for the kindness with which he has constantly assisted me in my researches.

My observations upon the developement of Hippocrene have therefore been limited entirely to the investigation of the eggs, as they appear during the time they remain connected with the maternal body. The eggs are developed in the outer layer of the walls of the main digestive cavity, under the layer of epithelium which covers that organ. They are imbedded between the transparent cells of the outer parenchyma, and appear at first as minute transparent vesicles, which grow rapidly, and increase the bulk of the central mass to such a degree as to change vastly its form (Plate II. Fig. 20, *c*, *c*, *c*, *c*, as seen from above). As soon as the eggs are ripe and ready to be laid, they assume (when seen from below) the appearance of four bunches of grapes united at their wider base, with the smaller end turned outwards (Plate II. Fig. 23, *f*, *f*, *f*). Fig. 4 of Plate I. represents a specimen with mature eggs, seen from above; while Fig. 1, 2, and 3, represent specimens deprived of eggs. After the eggs have been laid, the surface to which they adhered has a furrowed appearance (Plate II. Fig. 18); it seems folded, and isolated eggs may be seen still adhering in little depressions. These folds and depressions may be considered as a kind of *corpora lutea* left in a tissue containing no vessels, and assuming, therefore, a very peculiar appearance.

The eggs themselves, when mature, show distinctly a large germinative vesicle, more or less central, surrounded by a considerable quantity of yolk, consisting of granular cellular tissue of a yellowish-white color, inclosed in the vitelline membrane. Within the large germinative vesicle there is a single transparent germinative spot. Between the earliest formation of the egg and this state of development, in which the yolk has not yet undergone further changes preparatory to the formation of the germ, there are in the same ovary eggs of very different degrees of maturity, from the most minute transparent cells, already mentioned, up to larger and larger vesicles, with a more or less transparent yolk, and a distinct germinative vesicle and germinative spot. But the eggs do not seem to be all laid in the same state of development, for I have observed some still adhering to the central cavity, in which the yolk had assumed on its surface a mammillated appearance, forming a kind of mulberry-like body, probably the earliest stage of development of the germ; while others were laid before they had undergone any such changes. The fact of this inequality of development in the growth of the eggs in Hippocrene seems to be in accordance with the facts observed by Professor Forbes in the genus Lizzia, which is closely allied to Hippocrene, where real buds grow from the ovary, and are developed to a considerable degree before separating from the maternal body. In Hippocrene, however, I have never seen real buds arise in that way, but have uniformly seen the eggs cast before they had lost their spherical form.

The new genus of naked-eyed Medusæ to which I have alluded, and which resembles Hippocrene so closely, differs from it in having a more movable and bottle-shaped central digestive cavity, which may be more or less protruded from the main cavity of the body, and is not so persistent in its form as that of Hippocrene. The tentacles are arranged, as in Hippocrene, in four bunches, with eye-specks at their base; but there are two of these eye-specks supported upon two distinct stalks, rising above the others and above the tentacles, similar in appearance to the protruding eyes of a snail. Unfortunately, I was unable to have correct drawings of this animal made at the time when it was first observed. I subjoin a mere wood-cut, from a drawing made hastily at the time, by my son, Master Alex. Agassiz. The specimens were caught in the harbour of Nantucket, in June, 1849. For the genus I propose the name of Nemopsis, and shall call the species *N. Bachei.*



TIAROPSIS.

In its general outlines, the species upon which this genus rests is very plain. It has a hemispherical body of perfectly regular form, but of a very elegant appearance in its beautiful simplicity. Imagine a convex disk of transparent jelly, with a slight bluish milky tint, from less than half an inch to nearly an inch in diameter, somewhat like a deep watch-glass, with its margin fringed all round, and with the centre somewhat thicker, having a short proboscis in the middle, spreading into fringed lobes, from the upper side of which arise four tubes, diverging at right angles to meet the margin, with an elliptic or fusiform flattened swelling about the middle of their course, and eight deep black specks along the margin between the marginal tentacles, at the base of each of which there is a small black speck, and you will have as correct an image of the general appearance of this pretty little Medusa as a first impression may leave. When it is in motion, however, its form varies to a considerable extent, by the contraction of the muscles. When relaxed (Plate VI. Fig. 1), it is a very flat, saucer-like convex disk. When contracted (Plate VI. Fig. 2, 3, and 4), it assumes a more hemispherical shape, and when highly contracted, approaches nearer and nearer to a globular form. But in its state of high contraction (Plate VI. Fig. 6), the peripheric part of the disk is more or less detached from the central part by the stronger contraction of a muscular ring, forming a circle on the outer surface of the body above the tentacles. These forms pass gradually from one into the other: the margin may even be spread, and the centre so contracted as to give it a more globular form, when the outline of the animal assumes rather the shape of a church-bell. The circular outline of the whole body may also be somewhat modified, and assume a subquadrate appearance (Plate VI.

Fig. 7), but never to the extent which is observed naturally in Staurophora, unless in very powerful contractions after death, or during the violent spasmodic contractions preceding death, when specimens are sometimes seen to assume nearly the form of a four-rayed star (Plate VI. Fig. 8) when viewed from below, with a rounded disk above.

The movements of the animal are very graceful, and rather sustained. They are not, however, so powerful and energetic as in Sarsia, nor so abrupt and by starts as those of Hippocrene. It proceeds onwards or moves in all directions, upwards, downwards, or sideways, or changes its course in a direction opposite to that in which it was previously moving; and in all these evolutions it performs its movements in a very gentle and quiet way, full of grace and elegance, and has nothing of the quick, brisk, and I may say violent, movement which is so characteristic of Sarsia, — displaying in this mode of locomotion the difference of temperament there is between the species of the two genera, and indicating milder habits, and a less rapacious or voracious disposition.

Indeed, Tiaropsides are never seen to attack Medusæ larger than themselves. They rather feed on smaller prey, as very young Ephyræ, or on small particles of decaying animal matter. The shortness of their proboscis, and the lobed form of its margin, are in accordance with the indications derived from their way of moving. They seem rather adapted to suck their prey, than to take strong hold of it with a powerful proboscis, as is the case in Sarsia. They appear always in large numbers, gently sailing about, hither and thither, in the midst of the waters, with slight indications of activity, and are frequently chased by Sarsia, which prey largely upon them.

These little animals are the free Medusa state of animals very common on these shores, which have been long known under the name of Campanularia, and which are supposed to belong to the class of Polypi. But as I have been able to trace the whole transformation of successive generations of these animals, I shall in another part of this paper give a complete history of their development, limiting myself here to describing the particulars of their structure, in the full-grown condition of the Medusa state.

Like all other naked-eyed Medusæ, Tiaropsis has a gelatinous disk with a central digestive cavity, from which arise chymiferous tubes (Plate VI. Fig. 5), diverging at right angles towards the margin, where they unite with the circular tube extending all round the lower outline of the body along the base of the tentacles. This circular tube communicates freely with the vertical ones, and through these with the central cavity, so that chyme, which is elaborated in the main central cavity, is circulated to and fro in these tubes, without, however, passing into the tentacles, which are not hollow, as in Sarsia, but solid, as in Staurophora and Hippocrene. Within the margin, on the inner side of the circular tube, a thin nervous cord is observed, as in the other genera of this family.

The peculiarity in the tentacles of this genus (Plate VI. Fig. 3, 4, and 5) consists in their regular distribution all round the lower margin of the body, having each a small eye-speck at the base; but in addition to these, there are eight larger eye-specks (Plate VI. Fig. 3, 4, and 5, *c*, *c*), without tentacles, placed in the same row with the tentacles, but somewhat lower, and at equal distances from each other, being indeed, morphologically speaking, of the same kind as the smaller ones, only more individualized as organs of sense, standing out more prominently, and probably performing more decided visual functions, than the little black specks at the base of the tentacles. These eight ocelli, though in reality very small, nevertheless readily strike the attention of the observer from their very deep black color. They are placed (Plate VI. Fig. 5) in pairs between the radiating tubes, and rather near these tubes, so that the distance between them all is equal, there being none upon the tubes themselves.

The tentacles around the margin are so short, as to appear like an elegant little fringe all around. But the four radiating tubes are a striking feature in the appearance of these animals, not so much from their dimensions and prominence, as from the fact, that the ovaries or spermaries (Plate VI. Fig. 5, *a*, *a*, and Fig. 9, *c*, *c*) are attached to the middle of these tubes, in the form of elongated ribbons of a dark color, which bring out the position of the radiating tubes much more distinctly, and almost force the eye to notice the slender tubes (*b*, *b*) with which they are connected. Finally, the central proboscis (Plate VI. Fig. 3, 4, and 5, *e*), with its fringes (*i*, *i*), also attracts attention; and the whole animal may very well be compared to a diminutive umbrella, with four spreading rays, thicker in the middle, a very short handle in the centre, and light, delicate fringes with dark specks around the margin, swimming gently in the water, and moving voluntarily, with much grace, in all directions.

With regard to all the prominent features of its structure, Tiaropsis stands about intermediate between Sarsia and Hippocrene, especially in the arrangement of the alimentary system, and the fringes of the margin in their connection with the eye-specks. The proboscis (Plate VI. Fig. 9, *a*) is short; the central cavity is small, but it is not so completely shut up and permanent in its form as in Hippocrene, nor so movable and protractile and retractile as in Sarsia. It may expand (Fig. 12), unfold its fringes (Fig. 9, *b*), stretch itself in one direction or the other, adapt its outline to the bodies upon which it feeds, and display a great range in its movements and in the changes of form and extension which it successively assumes, without, in that respect, approximating in any measure to the extraordinary power of expansion and contraction which is so characteristic of the proboscis of Sarsia. If we could imagine the central cavity of Hippocrene (Plate I. Fig. 1) to be exceedingly movable, instead of preserving its fixed quadrangular form, and the lobe of its margin to be regularly undulating, more deeply cleft in sinuous outlines, instead of the regular dichotomal division which characterizes it; or if we could conceive the proboscis of Sarsia (Plate IV. Fig. 1) to be contracted within the main cavity of the gelatinous bell, to be shortened to about one fourth of the diameter of the main gelatinous disk, somewhat more than is represented in Plate V. Fig. 10, to be split about the opening, and the power of motion to be limited within this margin, rather than to extend to the whole cavity; then it would be seen how closely indeed these three genera resemble each other in the structure of their alimentary apparatus, notwithstanding the striking difference in its outlines. But it is important that such comparisons should be made, in order that we may fully understand that there is no difference — no organic difference — between those Medusæ which have a long proboscis, and those which have apparently none. This is the more important, as various authors have classified the Medusæ, and subdivided them upon the ground of the existence or absence of a proboscis; but we shall presently see that in such classifications Staurophora, Berenice, and other genera are entirely removed from the vicinity of Sarsia, Thaumantias, and Tiaropsis, when in reality they should be placed side by side, as I may show hereafter.

I have failed to trace nettling cells around the margin of the oral fringes and upon the tentacles of Tiaropsis, though I hardly doubt that they exist, with all the complication of the various kinds of lassos characteristic of all the appendages employed by these animals in securing their prey.

The main central cavity of the digestive apparatus is very small (Plate VI. Fig. 9, seen in profile, 10, seen from below, and 11, seen from above). It is a rather narrow funnel, divided into four tubes, radiating at right angles along the inner surface of the gelatinous disk, towards the margin of the animal. These tubes are funnel-shaped (Fig. 9, *d*) where they arise from the central cavity, but are soon narrowed into uniform tubes, extending without modification to the margin of the disk. The relations between these four chymiferous tubes and the circular tube of the lower margin of the gelatinous disk are precisely identical in the genera Tiaropsis, Sarsia, and Hippocrene. There is the most free communication between them. The chyme is circulated to and fro from the central cavity into the radiating tubes, and from these into the circular tube, and *vice versâ*. There is, however, this marked difference between the three genera, that in Sarsia there is but one eye-speck with one large tentacle arising from the junction of each radiating tube with the circular tube; in Hippocrene there are bunches of tentacles with eye-specks arising from the same position; while in Tiaropsis the tentacles are uniformly arranged all round the disk, without the free spaces existing in both the former, in which the margins between the radiating tubes are entirely destitute of either eye-specks or tentacles, these being altogether limited to the junction of the radiating tubes with the circular tube. In Tiaropsis, however, the tentacles and eye-specks are not only uniformly distributed along the whole margin without any prominent tentacle or eye-speck at the junction of the tubes, but between the tubes there are, all round, two larger eye-specks, making altogether eight, arranged at equal distances in the intervals between the radiating tubes. This peculiarity is the more striking, as in most of the naked-eyed Medusæ the development of eye-specks seems to be prominently connected with the vertical chymiferous tubes and the marginal tentacles; while here the eye-specks are decidedly a morphological modification of the marginal appendages, being homologous to the tentacles with a simple eye-speck at their base, with which they are placed in one row and upon one level, differing in the degree and intensity of development, assuming a much more independent position, and leading almost to the peculiar arrangement characteristic of the common large Steganophthalmic Medusæ. The tentacles are not hollow, and no chyme is circulated in their interior in a more special manner than must take place everywhere in the process of assimilation. But here the chyme, as such, is not circulated in particular ramifications of the circular tube beyond the margin of the disk, while in Sarsia it penetrates into the four marginal tentacles. The tentacles all round the margin of the disk are of nearly uniform length, and of uniform size and thickness; though, upon close examination, sufficient differences may be perceived between them to satisfy us that their number is constantly increased by the additional development of new ones between the older (Fig. 13). This is especially striking upon comparison of very young specimens of Tiaropsis with more advanced ones, the number of tentacles being hardly one fourth of what it is at a later period, or, as the development is rather uniform in these animals, and almost all specimens caught at the same time are nearly equally developed, the comparison has to be made from recollection and memoranda of earlier states of growth contrasted with mature specimens, when it becomes plain that the eight large eye-specks, with few intervening tentacles, are developed very early (Fig. 14), and numbers of tentacles, with rudimentary eye-specks, are successively formed in the intervening spaces of the older ones (Fig. 15); but the larger prominent ocelli (Fig. 16), while they undergo their gradual development, remain unchanged in number, there being but eight of them throughout life. Their position, also, is rather singular: they are all at equal distances from each other (Plate VI. Fig. 5); but, with reference to the radiating tubes, they are placed so that one radiating tube meets the circular tube exactly midway between two eye-specks, thus dividing the continuous track of the circular tube extending between two such eye-specks into two equal parts, while between the next eye-specks the circular tube runs undivided and unconnected with radiating tubes, there being only four of these latter ; but next, again, a radiating tube reaches the middle of the space between the two following eye-specks ; and so on, in such a manner that there are alternately two eye-specks on the two sides of a radiating tube, with two eye-specks between two radiating tubes, at a distance from each other of twice that from the tube to the eye-speck. This singular alternation is quite a prominent feature of the genus Tiaropsis, and seems to me the more interesting, as, up to the present time, it is the only known instance of the kind, and has not been noticed among the numerous otherwise similar forms which occur on the British shores, and have been so minutely described by Professor Forbes. Like the tentacles of Hippocrene, which are also destitute of an internal cavity, those of Tiaropsis elongate and shorten to a considerable extent (Plate VI. Fig. 13) ; but their power of extension and contraction can by no means be compared to what we see in Sarsiæ, which, at times, seem almost to drop their tentacles, so suddenly are they extended without any apparent action of the animal, and then draw them violently in again.

The eye-specks at the base of the tentacles are simply an accumulation of pigment-cells, closely packed together without apparent order or regularity. But not so with the large eye-specks. Each of them (Plate VI. Fig. 17) has within its base a large mass of very black pigment-cells, *a*, forming a sort of nucleus to a ganglion analogous to that of Hippocrene, in the formation of which the sensitive substance seems to take a considerable part. This ganglion is crowned by a diadem-like double wreath of peculiar cells, the inner row of which, *b*, may be compared to the basal eye-specks of the bulb of Hippocrene. There are about eight or nine such larger pigment-cells, forming a crescent at some distance from the opaque nucleus of the bulb ; and above this rises another row of most elegant transparent pearl-like cells, *c*, encircling the former, which may be compared to rudiments of as many tentacles. If this view of the structure of these eye-specks is correct, each of them would correspond to one bunch of eye-specks, or one bulb, of Hippocrene ; but of these bunches there would be eight in Tiaropsis, alternating with the radiating tubes instead of being connected with their base, and, in addition to these, a large number of simple tentacles with rudimentary eye-specks. I may be mistaken, but I cannot help being deeply impressed with the diversity of structure which exists among these lower animals, which is so great that the necessity of extensive comparisons between these structures, in order to ascertain their homologies and relations, seems to me almost of greater importance than among the higher animals ; or, at least, as urgently called for to advance our science. Again, is not a comparison between the clusters of eye-specks in Hippocrene and the compound eyes of insects almost involuntarily called forth here? And would it not be equally natural to extend similar comparisons to the larger eye-specks of Tiaropsis, and to view the small dark dots at the base of their tentacles as corresponding to the loose ocelli scattered more irregularly in spiders and other insects?

The position of the ovaries and spermaries (Plate VI. Fig. 3, 4, 5, 9, and 10) seems at first entirely different from that which exists in either Hippocrene or Sarsia. In those two genera the eggs and spermatic cells are developed, (as mentioned above,) upon the whole surface of the central digestive cavity. But in Tiaropsis they form four isolated bunches, placed upon the lower surface of the gelatinous disk, about midway between its central part and its margin, following, however, the radiating chymiferous tubes, to the external surface of which they are attached. This connection of the ovaries and spermaries with the radiating chymiferous system in Tiaropsis is certainly the same, morphologically, as in Sarsia and Hippocrene; though in the two latter genera the eggs and spermatic cells seem to be connected only with the outer walls of the central digestive cavity. However, if the arrangement of the ovaries in Hippocrene be examined very carefully, and their connection with the prominent angles and lateral surfaces of the central cavity be not lost sight of, it will indeed be seen that the development of the bunches of eggs corresponds strictly to the prominent angles of the central cavity, from which the radiating tubes arise, and which the eggs, in their development, follow to some extent before they are laid, as may be seen from Plate II. Fig. 23. Thus the whole difference between the sexual system of Tiaropsis and Hippocrene consists in the circumstance that the four angular bunches of ovaries, or spermaries, characteristic of Hippocrene, are somewhat displaced from the centre, and moved halfway towards the edge of the disk, to form the characteristic isolated ovaries and spermaries of Tiaropsis. Organically speaking, however, this difference is so trifling, that I should not be willing upon this basis to establish distinct families, as Professor Forbes has done; for morphology teaches us here, that there is no more difference in the position of the ovaries and spermaries in Tiaropsis and Hippocrene, than there is between the connection of petiolate and decurrent leaves with the stem to which they are attached.

At various periods during spring these organs appear very differently, being at first scarcely distinguishable as a slight ribbon-like swelling along the middle track of the radiating tubes. Later and later, as the ovarian and spermatic cells are more and more developed, they form a larger and larger fusiform body, swelling finally into prominent granulated bunches, varying in color in different specimens, from which at last the eggs are hatched. The state of development of the eggs, when they are cast, is rather advanced; for the germs are then ready to escape, or are indeed actually freed from the eggs, before their envelope is cast from the ovary, the yolk undergoing the whole process of division before the eggs are laid, and the germ, when thus hatched, having a somewhat ovate form, but still a very uniform homogeneous structure. Such germs, recently hatched from eggs, I have seen move slowly, then attach themselves to the solid bodies in the jars in which they were kept, and grow into a Campanularioid polypidom, the history of which I shall give in another part of this paper. After the eggs have been laid, the ovaries are considerably reduced in size, and presently dissolve, when the animal soon dies. When forming, the eggs present all the characteristic structure of eggs in general, and hang in bottle-shaped sacs from the lower surface and the sides of the chymiferous tubes. I would only add, that I have repeatedly noticed a minute dot within the germinative spot; but of all the changes which the eggs undergo, I shall speak more fully when illustrating their metamorphoses.

Notwithstanding the very flattened form of the disk when compared with that of Sarsia, we may trace in these little spreading bells the same general arrangement of muscles as in Sarsia and Hippocrene. But it requires greater care to trace it fully, and it is more difficult to reproduce, in distinct appreciable drawings, the bundles which have been traced in highly contracted and distorted dead specimens. However, it is easy, in the first place, to see in living specimens, that the movements are entirely the same, and that the differences arise chiefly from the energy with which they are performed, in connection with the different permanent shape of the gelatinous disk. This disk being flatter, its margins thinner, and the lower partition, which extends inwards from the margin within the tentacles, narrower, the partition controls less powerfully the general motions than is the case in either Sarsia or Hippocrene, in neither of which do we ever see the lower partition unroll and turn inside out, as is so frequently noticed in Tiaropsis. This arises from the circumstance, that the partition is not only more lax and floating, but also narrower in comparison with the width of the gelatinous disk, and its spreading form. The muscular fibres in this partition are, as in the other genera, concentric and circular, combined with fewer radiating ones. The concentric fibres are by far the most prominent; their linear arrangement and cellular structure are easily seen, perhaps with even more ease than in any of the other types (Plate VI. Fig. 18).

The muscles of the disk are arranged precisely as in Sarsia or Hippocrene. There is an external superficial system of bundles hanging over the gelatinous mass, and simply covered by an epithelial film, which forms the outer coating of the body. This system is particularly loose and difficult to trace towards the periphery. This difficulty arises from the unfolding of the disk near its margin, where it is thinned out and readily bent outwards, and even upwards, as soon as the dying animal sinks and lies flat upon the bottom of the glass plate, upon which it is brought under the microscope. It is therefore of the utmost importance to be first thoroughly acquainted with these changes of form of the whole animal, and especially with the unnatural fold which is formed at some distance from the margin in the contraction of death, before any further attempt is made to investigate the connections of the muscular apparatus of either the surface or the inner cavity of the disk. As soon, however, as we are familiarized with this difficulty, it is easily ascertained that there are in the disk three muscular systems, as in the preceding genera. For, besides the superficial system already mentioned, we trace, with the same ease, another on the inner surface of the gelatinous disk, which has the same general arrangement, its main bundles alternating with the radiating chymiferous tubes, and smaller bundles arising between these and the tubes; so that there are four chief bundles extending from the summit towards the lower margin of the inner surface of the gelatinous mass, and eight smaller ones alternating between these and the radiating tubes, besides some fibres which follow the tubes and have a more pennate arrangement. The only difficulty there is in tracing these muscles is in ascertaining that the superficial bundles and the inner bundles constitute two distinct systems; for here the gelatinous disk is so much thinner than in either Sarsia or Hippocrene, as to leave it frequently doubtful whether we have the fibres of the upper, or those of the lower surface in the focus of the microscope. Again, owing to the unrolling of the margin where the fold of the peripheric part of the disk is formed upon the more massy portion of the centre, there seems always to be a complete interruption in the course of the muscles; so that it requires more practice with these animals than with other genera before their contractile fibres can be traced for their whole length, the radiating chymiferous tubes themselves seeming frequently interrupted at the same place. I mention this difficulty for the sole purpose of removing at once the doubts which might arise in the minds of naturalists induced to repeat these observations, who otherwise might not at first perceive the cause of a discrepancy between the illustrations given here, and the appearance of specimens as they are seen at times under the microscope, though these circumstances have no reference to the real structure of the animal itself.

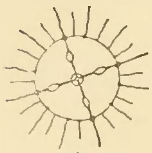
The third muscular system of the disk lines, with concentric circular fibres, the inner cavity, or rather the lower surface of the gelatinous disk. This system seems to be very powerful, even more so, comparatively, than in other genera; and, if we are allowed to trust the appearances, there seem to be, at a slight distance from the tentacular margin, about the lower extremity of the ovaries, stronger bundles of these fibres, which, when fully contracted, break the regular continuity of the outlines of the surface, forming a sort of stricture between the upper disk and its margin. The circumstance that such contraction is observed in almost every dead specimen, while we hardly ever see the circular outlines of the lower margin deeply lobed or contracted into quadrangular outlines, plainly shows that in this type the circular muscles are more powerful than the radiating bundles of fibres. At the utmost, we notice slight undulations in the lower outline of the tentacular margin, between the radiating tubes, reminding us of the greater strength of the inner radiating muscles; the outer seem so delicate as to come into play only in connection with the inner, and perhaps to stretch the margins in the state of relaxation of the circular bundles and the lower radiating ones. At all events, the greater looseness of the outlines, the thinness of the disk, especially towards its margin, and the greater range of changes in the regular forms, agree with the particular modes of moving and feeding characteristic of this genus.

It were now very interesting to ascertain how far, among the numerous types allied to those which occur on the British shores, there is any resemblance in the arrangement or the greater development of their eye-specks, and the peculiar structure which characterizes the genus Tiaropsis. From Professor Forbes's descriptions, there seem to be no differences in the size of the eye-specks in any of his species of Thaumantias, to which genus I would have referred my Tiaropsis, were it not for the existence of two kinds of eye-specks around the margin, and the peculiar structure of the larger ones. I have given the name of Tiaropsis to this genus on account of the very peculiar structure of the eye-specks, of which no other example is yet known among Medusæ. For the species I would propose the name of *diademata*, as expressing more particularly the double wreath of the crown-like eye-bulb. The species is extremely common along the wharves of Boston harbour, and indeed throughout the bay, where it is constantly found near the surface, among Sarsiæ and young Ephyræ, early in spring and until about midsummer, when they disappear, soon after having laid their eggs.

In an ideal vertical section of Tiaropsis (Plate VIII. Fig. 11), corresponding in its position to that of Hippocrene, Fig. 3, and to that of Sarsia, Fig. 5, the relative position and natural connections of parts are illustrated in such a manner as readily to show the generic distinction between these types, and the homology of their different systems of organs. Without entering into any further details upon this subject, I will only mention that the letters in all the figures correspond precisely to each other, and may therefore, with ease, be referred from one genus to the other.

THAUMANTIAS.

On comparing the Fauna of the British coast with that of the United States, for their Medusæ, there appears a very striking difference between them; for, though some of the types occur on the two shores, there are others which seem peculiar to each. No doubt this difference, great as it appears at present, will be gradually lessened as more and more extensive investigations are made among the Medusæ of the American shores. Had not Professor Forbes devoted so many years to the study of this class, we should certainly be unacquainted with so great a diversity of British Medusæ as he has so well described. However, the occurrence of so large a species as Staurophora among the few Medusæ noticed on the shores of Massachusetts, when nothing of the kind has been noticed on the shores of Great Britain, after the thorough search made by Professor Forbes and Captain McAndrew, indicates plainly that the two countries do not agree fully in their Acalephæan Fauna. We have here Aurelia, Cyanea, Rhizostoma, and Pelagia among the large Medusæ, as they occur also on the shores of Great Britain; but no Chrysaora, nor any Cassiopea, has yet been found here, nor have representatives of the genera Willsia, Circe, Oceania, Saphenia, Turris, Stomobrachium, Tima, Geryona, Slabberia, Moderia, Geryonopsis, Lizzia, Steenstruppia, and Euphysa been found. But here we have Staurophora, which does not occur there; and the genus Thaumantias, of which so many species have been discovered on the British shores, has yielded only two representatives on the American shores, up to the present day; while a species closely allied to Thaumantias is found in great abundance on the shores of Massachusetts, but differing from the true Thaumantias in peculiarities striking enough to constitute a genus by itself, of which no analogous representative has yet been found elsewhere. For that genus I have proposed the name of Tiaropsis, alluding to the peculiar form of its eyes, which are not connected with the tentacles, but alternate with them, and are surrounded with a crown of globular vesicles, forming a diadem above the black speck. Another genus peculiar to the United States is my Nemopsis. The first species of Thaumantias proper which I observed in this country was caught off Gay Head, and in Edgartown harbour, under circumstances which did not allow me to have it drawn with sufficient details, and to investigate its structure with any degree of accuracy. All I could do was to ascertain that it truly belonged to the genus Thaumantias, having round the margin short tentacles with an eye-speck at their base, the tentacles being alternately longer and shorter, one of the longer arising from the base of the four radiating chymiferous tubes, and two of the same length intervening between two tubes, and alternating with shorter ones; the mouth forming, as in the other species, a small bell-shaped peduncle, with four lobes spreading sideways and fringed along their margins; the ovaries attached in the shape of ovate bodies on the lower side of the chymiferous tubes, about the middle of their length. This species is very minute, scarcely a line in diameter, and perfectly transparent and white, excepting the dark eye-specks at the base of the tentacles, the ovaries having a light tint of yellow.



1.

2.

I propose to call this species *Thaumantias diaphana.* I subjoin a wood-cut of the rough sketch made at the time. It was dredged with a gauze net from the surface, on the 25th and 26th of June, 1849. Fig. 1 represents this little Medusa as seen from above; Fig. 2 shows it in profile.

While this sheet was passing through the press, Mr. Charles Girard, my assistant, brought me another species of Thaumantias, taken by him on the beach at East Boston. Though it was in a rather indifferent state of preservation, I could satisfy myself that it differs specifically from the former, inasmuch as it has narrow, elongated ovaries; thus showing that the two types of Thaumantias which have been noticed in Great Britain occur also along the shores of the United States. The size and time of appearance speak also in favor of the specific difference of these two Medusæ, as the first, observed towards the end of June, was very small, and the other, caught early in May, was a full grown-animal, over one inch and a half in diameter, and similar in form to *Thaumantias Pilosella.*

STAUROPHORA.

The genus Staurophora was established in 1835, by Professor Brandt, in his Prodromus of a Description of the Animals collected during a Voyage round the World by H. Mertens, published in the Transactions of the Imperial Academy of Sciences of St. Petersburg, in 1835.

The genus was established by Brandt from the drawings and memoranda of Mertens. Afterwards, a fuller account of it was given by Brandt, in his extended Description of the Medusæ collected by Mertens, published also in the Transactions of the Imperial Academy of St. Petersburg, in 1838, Sixth Series, Part Second, Vol. II. p. 399.

The genus is characterized as follows: — No mouth, according to Mertens; — on the lower surface numerous arms, (fringed folds of the margin of the mouth,) which form two stripes or ribbons alternating with each other in such a way as to constitute a cross ; — the margin of the disk furnished with numerous tentacles.

This new genus is there represented as differing from Eudora by the presence of suckers and marginal tentacles; and from Berenice, which possesses long marginal tentacles, in the foliaceous arms arranged in the shape of a cross. In the possession of arms it shows a resemblance to *Medusa campanulata* [*Melicertum*]. But this latter genus has thread-like arms, and the tentacles around the margin are in several rows, of unequal length. The specific description there given, and the figures reproduced from Mertens's drawings, under the name of *Staurophora Mertensii*, afford some further information upon this remarkable animal.

It is described as being slightly convex, clear as water, and perfectly transparent. Each arm of the cross, which is tinged more or less deeply with blue, possesses on each side from seventeen to twenty-one arms, each of which has a lanceolate or a linear-lanceolate and undulating or fringed margin and acute terminations. The arms hang downwards with their free margin, but remain united at the base by a narrow continuous membrane extending for their whole length, from which issue a few additional small processes or appendages.

Brandt says that it may be possible, as Mertens maintains, for these arms to absorb nourishing substances, in a manner analogous to that of the Rhizostomata, in which the arms, however, have a different structure. The fact that the four peripheric extremities of the arms of this cross terminate in a distinct marginal vessel would sustain this view. Numerous tentacles, by no means remarkable for their length, are in connection with this marginal vessel. Within the margin to which the tentacles are attached, there is a prominent seam.

The movements of this animal are very characteristic. It can, not only change its form and place after the fashion of other Medusæ, but also contract in such a manner as to assume the form of a regular four-rayed star, thus somewhat resembling an Asterias ; this form it assumes very frequently.

The first specimens of this Medusa were collected in Norfolk Sound ; it was observed afterwards in the ocean of Oonalaska, and finally, on the 20th of August, 1827, it was seen from the Senjevin on her trip between Sitka and the Aleutian Islands.

This is all we know at present about this remarkable form of Medusa, as nobody has ever seen any animal of that genus before or since. Its natural position among Discophorous Medusæ is rather doubtful. Brandt places it, with doubt, in that family which

Eschscholtz established in 1829, under the name of Berenicidæ, for two genera circumscribed before by Peron, of which he himself never saw any representative.

Eschscholtz himself is not very precise in his characteristics of the family Berenicidæ, as he only mentions that these animals are reported to have no digestive cavity, but simply ramified vascular tubes, which probably absorb their food by a number of apertures, or perhaps short suckers, in which respect he says they would resemble Rhizostomata. The only genera known, Eudora and Berenice, were established by Peron. Their disk is rather flat, but the genus Eudora is characterized by a want of marginal tentacles; Berenice, by the presence of rather long appendages of this kind.

Brandt adds to the rather meagre characteristics of the family Berenicidæ, as established by Eschscholtz, that this family is probably not to stand, though he does not give any reason for his opinion, nor does he mention where his new genus Staurophora should be referred, in case Eschscholtz's family were broken up. However, that Staurophora is really closely allied to the two genera of Peron, which constitute Eschscholtz's family of Berenicidæ, cannot be doubted for a moment, from a comparison of the figures of Peron with those of Mertens published by Brandt. Such is the amount of our knowledge, or rather the deficiency of our knowledge, respecting some of the most important details of the structure of Medusæ, that we are at a loss to assign to this group of jelly-fishes their proper natural position, until further investigations are made upon the subject.

There is something so repugnant to the physiologist in the thought of animals of the size of Staurophora, that is to say, measuring several inches in diameter, being deprived of mouth and stomach, that, of all the naturalists who have read attentively such descriptions, there is probably not one who has been willing to regard this as really a correct account of these animals, who would not have considered himself peculiarly fortunate in having an opportunity of reinvestigating carefully such types, and who would not, under such circumstances, make a reëxamination of the alimentary canal, and a search for the stomach and mouth, the first object of his investigation; so little are we prepared, and so little reason is there, on the whole, to give credence to assertions which come in direct conflict with the most carefully established results in physiology.

I have scarcely ever valued any discovery more highly than that made by my secretary, Mr. H. Huber, of one specimen of well-characterized Staurophora, in Boston harbour, in the early part of the summer of 1849. My first care was to look for the central cavity, and an external opening communicating with it; and I must say, I had scarcely looked, when I found both; but I must also confess, that I do not wonder that neither was discovered before.

Let me first state, that the species found in Boston harbour belongs really to Brandt's genus Staurophora; for if there should be any doubt upon this point, all further generalization might be perfectly unfounded.

Staurophora is a genus of Discophorous Medusæ. My new species resembles so much, in its general appearance, the common Medusa (*Aurelia aurita*), that the first specimen, which was brought to me by Mr. Huber, came in a jar of specimens of that species, for which I had sent, and was brought up without being noticed. I, however, afterward secured a great number of them, which were collected both by Mr. Charles Girard and Mr. Huber, so that I have had ample opportunity to study fully the form and structure of this animal, which is really an intermediate type between Eudora and Berenice, having rather short marginal tentacles, similar, indeed very similar, to those of Thaumantias; and our species might easily be mistaken for something like *Thaumantias Pilosella*, were it not for the want of central oral lobes or stomachal appendages, instead of which we notice a simple cross extending nearly to the very margin of the animal, and consisting of a membranous seam hanging downwards, in a manner almost identical with that of *Staurophora Mertensii*, but differing, however, in its lobulation, the margin of these membranous seams being only deeply undulated, but not pectinate.

The motions of the species of Boston Bay agree also remarkably with the description given by Mertens of the species observed on the northwest coast of the American continent. When progressing slowly, they advance like all Discophorous Medusæ, by alternately expanding and contracting the margin of their disks, and assuming successively the appearance of a disk or that of a half-sphere. In this respect they closely resemble the common Medusæ. But when they contract more powerfully, they assume a very different aspect. The angles of the cross become prominent, and the intervening spaces are contracted in such a way as to give the whole disk a quadrangular form, or even that of an emarginate four-rayed star, precisely as Mertens has observed it in his species described by Brandt. The resemblance in form, in movement, in the position of the marginal tentacles, in the disposition of the arms, as Brandt called the fringes forming the cross on the inner lower surface of the disk, can, I trust, leave no doubt in the mind of any naturalist, that the Medusa I am about to describe really belongs to the genus Staurophora of Brandt.

It cannot be doubted, therefore, that whatever additional details of structure may be observed in one will also sooner or later be discovered in the other; and whatever conclusion may be established respecting their systematic position will equally apply to Eudora, Berenice, and Staurophora.

Now, in the first place, I would mention that the disk presents a mass of gelatinous substance, contained in rather large cells, like those of the vitreous humors of the eye, covered externally by a flat pavement epithelium of irregular nucleated cells, forming a film which is deciduous soon after the animal has perished; but even during life, after injuries upon the surface, this coating is seen to peel off, and the animal gradually decays by superficial decomposition.

The disk is flat-hemispherical, its margin more or less expanded as the animal is in a more relaxed or contracted state. Muscular fibres run in two different directions through its whole mass; part of the fibres being radiate, and others concentric. The radiating fibres are in larger bundles, and appear particularly active upon three points in each of the four intervals embraced by the four arms of the cross; there is, however, also a bundle in the prolongation of the ray of the cross itself, and similar smaller bundles alternate again with those already mentioned. So that, upon contraction, its radiating muscles may cause the disk, or at least its margin, to fold into more or less numerous lobes, according to the intensity of contraction of the more powerful of these bundles.

The concentric muscles are disposed in such a manner as to form concentric squares rather than concentric circles, the sides of which extend from one arm of the cross to the other; and upon strong contraction, assisted by the main radiating bundles which alternate with the rays of the cross, they give the animal in its most powerful contractions the appearance of a square body rounded upwards.

The diversity of forms and appearance which this animal may assume in its contractions is so great, that I have been induced to multiply the figures representing it, in order to give a full idea of their distinctive peculiarities. It was the more important to do so, as in a dying condition they would at times assume permanently one or the other of these forms, which, if observed singly, might easily be mistaken for a special modification of structure, and give rise to an erroneous distinction of species. But as I have observed these animals for days and weeks, I know that these are only temporary modifications of the same species, as I have seen the same individual present, at different periods, all the forms here illustrated. (Plate VII. Fig. 1 – 8.)

We must consider as the margin of the disk the edge from which the tentacles spring and hang down, though this edge is more or less curved in when the animal is in gentle activity, as this is the most prominent margin when the animal is in the greatest state of relaxation, and spreads almost flat like a disk (Fig. 9). The tentacles are very numerous, seemingly of equal length and size; yet upon close examination it may be seen that there are thicker and thinner, longer and shorter ones, alternating with each other; but the difference is so slight as, at first view, not to strike the observer. Their length is less than half the diameter of the disk, even in their most relaxed state. Usually they form only a graceful fringe all round the disk, about one sixth of the whole diameter in breadth.

These tentacles are hollow, and their cavity, which is wider near their base than towards the tip, opens into a circular canal, which extends all round the disk along the bases of the tentacles. Underneath and within the tentacles, there is a further prolongation of the disk, in the shape of a seam stretching inwards, and forming, as it were, a partition of the cavity below the disk. But as this seam is rather narrow, the cavity itself is widely open, and the seam, in general, can hardly be considered as any thing more than a mere membranous inner prolongation of the disk, or of the margin of the disk, from which the tentacles issue. The existence of such a seam should not be overlooked, as it is a point in the structure of the Medusa under consideration which is probably common to all the genera, and only more or less developed in the different types. For instance, the inferior opening of Hippocrene is very small in comparison with the whole width of the animal, which, consequently, has the lower surface of its disk almost shut out from immediate contact with the surrounding water. Such is the case, also, in the genus Sarsia, whilst in Thaumantias, as in Staurophora, the flatness of the disk and the narrowness of its inner seam make this feature less prominent. As in all the Medusæ in which it has been observed, this seam is contractile ; concentric fibres prevailing in it, though there are also a few radiating ones, by the powerful contraction of which this seam is at times reversed outwards, so as to cover the base of the tentacles. Specimens which have died in such a position might also easily be mistaken for peculiar species.

At the base of each tentacle there is, on its inner surface, a black eye-speck, varying in size in proportion to the size of the tentacle itself. The form of these eye-specks is less regular than in most other naked-eyed Medusæ; the pigment-matter forming rather irregular heaps, dark in the centre, with the margin vanishing away into the surrounding substance. But, however indefinite these specks may be, (and they appear as perfectly distinct dots to the naked eye, and only under higher magnifying powers seem less defined at their margin,) they must, physiologically speaking, be considered to be the same organs as similar specks upon the margin of the disk of most other Medusæ. The tentacles themselves, in their contraction, are not only shortened and lengthened; but they coil spirally, and the coil is twisted from right to left downwards, or from left to right upwards, all around the disk, without antitropic direction of those of different parts of the periphery.

The diversity of the forms which Staurophora assumes is truly wonderful. It may appear as a flat disk entirely spread out, the marginal tentacles spreading also in the same plane. Or the disk may be swollen slightly into a flat hemisphere, with a uniform curve from the margin to its summit, the tentacles hanging down at right angles all around (Plate VII. Fig. 10, 11). Or the prominent disk may be more swollen in the centre than towards the margin, which may spread, while the central part of the disk is considerably raised. Again, the whole disk may be contracted so much as to form a regular rounded hemisphere (Plate VII. Fig. 1), with hanging marginal threads; or the margin may be still more contracted, and give the whole body an almost spherical shape, when the lower opening is perhaps reduced to half the diameter of the globular body.

Again, the muscles may contract in such a manner, as to give a quadrangular form to the disk with rounded angles, and the upper portion may be more or less raised (Plate VII. Fig. 8). In such a position, the margins are inflected inwards between the arms of the cross, and the fringes form also a more or less quadrangular fringe, and the inner seam is bent over between the arms of the cross, and covers them more or less. If, in such a position, the animal contracts still further, and the radiating muscular bundles between the arms be particularly active, the quadrangular shape of the outline may be still more brought out, and it may even assume the form of an emarginate four-rayed star, when the inner seam covers almost entirely the arms of the cross, and shuts completely the lower surface. In that case the marginal fringes are bent inwards, and the lobes in which they are inserted form, as it were, four valves, moving up and down, and alternately opening and shutting the lower cavity. Finally, the contraction of the radiating muscles may be such as to divide the fringed margin into more or less numerous lobes (Plate VII. Fig. 7), which may form an undulating circle, or more or less prominent lobes almost as completely isolated as if they were separated by fissures.

In order fully to understand the structure of the central cross of the lower surface, it is necessary to be acquainted with the morphology of the mouth of other Medusæ, and to have traced its successive changes in some of the higher Medusæ, from its earliest condition up to the time when it assumes there its most complicated structure.

In the young Aurelia, the mouth is a mere quadrangular opening, with prominent margins. These margins, however, soon project; the angles become more prominent, and then elongate; and this elongated portion at length widens and is enlarged into flat tentacles, frequently called by zoölogists the arms of the mouth. In the perfect adult Aurelia, the mouth is a simple cross-fissure, with prolonged thin, membranous margins. The margins of each arm of such a cross are laid flat against each other, and constitute compressed channels opening into the mouth.

Now let us for a moment suppose that such a mouth, instead of being confined to a limited space of the central portion of the disk, were to extend, as a long, radiating arm, from the centre to the periphery, and that its margins were not elongated, but consisted merely of narrow ribbon-like membranes laid flat against each other, and following the fissure of the mouth with uniform width for its whole extent, and that its membranes were more or less lobed along their whole margin, and we should have the mouth of Staurophora.

Indeed, in our Medusa this cross consists of a narrow fissure in the centre (Plate VII. Fig. 15 and 12), towards which the four arms converge; and each arm of the cross, when properly examined, is found to consist of a narrow fissure, inclosed by two membranes pressed against each other; but the lower margin of each diverges somewhat, and is undulated and lobed for its whole length. Near the periphery, however, the two membranes of each arm converge and unite (Fig. 13 and 14), and thus close the fissure completely, and turn it into a narrow tube, which extends further and communicates freely with the circular tube extending along the base of the tentacles. Upon unfolding these double membranes along each ray, it is easy to penetrate into the fissure between them, and also to ascertain that this fissure is continuous, and that the fissures of the four arms of the cross meet in the centre in an oblong open space surrounded by folds inclosing the four fissures, which meet here in continuous lobes, and thus form a free entrance to the central cavity, which extends into the arms.

There can be, therefore, no mistake about the real nature of this open space, and the fissures with which it communicates. The central opening (Fig. 12, *a*) is the mouth; the four fissures of the four arms of the cross are its extensively prolonged angles; and the fringes which encircle them are the ribbon-like fringed margin of the mouth, and are truly homologous with the mouth of all other Discophorous Medusæ. So that Staurophora, far from being destitute of mouth and stomach, is formed upon the same plan with the common Discophorous Medusæ, with this single difference, that the opening of the mouth is very narrow and small, and somewhat oblong, and its angles very prominent externally, and unusually developed.

But we have direct evidence that this cross-like opening is really the mouth, and that its whole extent is to be considered as the opening of the mouth, and the central cavity more properly as the main cavity of the body: for I have often seen this Medusa feeding upon other species of small size. In a glass jar, in which I kept alive for weeks specimens of Staurophora with various kinds of Sarsiæ, Tiaropsides, and young Aureliæ, I have often seen the Staurophora seize upon the smallest of these animals, inclose them between the folds of its central cross, and swallow them gradually, completely surrounding them by its folds. Such small Medusæ were seized, not only by the central portion of the star-shaped fissure, but also upon any point in the extent of the star, and at times I have even seen two Sarsiæ entangled between the folds of the mouth, one at the very peripheric extremity of an arm of the cross, and the other near the middle of another arm, as represented in Plate VII. Fig. 11. So that there cannot be left a shadow of doubt as to the real nature both of this fringed star and its fissure, as well as the central open space.

Staurophora has, we can say positively, a narrow, oblong mouth, with extensively prolonged angles reaching nearly to the margin of the periphery, where the folds converge and unite, and give rise to a narrow vascular radiating tube, identical with the chymiferous tubes in Sarsia and Thaumantias, and other naked-eyed Medusæ. In Staurophora the only difference is the relative shortness of these radiating tubes, which are shorter than in other genera in proportion to the greater extent of the cavity of the mouth; but here, as in all, the mouth, central cavity, and radiating tubes communicate with the marginal circular tube, and through it distribute the digested food into all parts.

Respecting the form of the central cross, I have further to remark, that in our species the fissure formed by the folds of the membrane of the mouth is undulated in its course, as well as the membrane itself, and that the lower margin of the membrane is deeply but irregularly lobed. In that respect the species from Boston Bay differs from that of the Northwest Coast, in which, to judge from the figure of Mertens, the canal is straight, and, as expressly mentioned by Brandt, the surrounding membrane, which hangs down, is deeply cleft into fringed distinct lobes; so that there can be no doubt as to the specific distinction between the two species, though they otherwise agree closely. From the peculiarities just described, I propose to call the Eastern species *Staurophora laciniata*, Brandt having named the other species after its discoverer, the able and lamented Mertens.

I have little to say respecting the organs of reproduction, as my specimens were collected at a season when the eggs did not seem to have advanced far in their development. I can only state that they are grouped as in Thaumantias, along the radiating chymiferous tubes, where they form a narrow elongated cluster, extending from the extremity of the cross along its fissure for some way towards the centre, where they are lost at about one third of its length. How large the eggs grow before they are mature has not been ascertained, nor could their microscopic structure be satisfactorily investigated, as they seem more closely imbedded in the substance of the disk than in other species, and are always crushed when separating the fringes from the disk.

Staurophora laciniata has a light, bluish milky color, and is very transparent, though less so than most of the species of naked-eyed Medusæ. I have, for that reason, been unable to make out distinctly the nervous ring, which, in other species, follows the circular marginal tube, though I observed a thread accompanying it, which may correspond to the distinct nervous cord noticed in Sarsia, Tiaropsis, and Hippocrene. The marginal fringes are of a light rosy color, and the folds of the mouth either rosy or yellowish.

From the preceding description, it must be plain that Staurophora belongs to the same family with Thaumantias and Tiaropsis. These genera agree in every respect in their structure, and the differences which occur between them can only be considered as generic. In all, we observe the same narrow central cavity, with a narrow fringed mouth; in all, chymiferous tubes arise from the central cavity, and communicate with a peripheric circular tube; in all, we have slender tentacles connected with the margin of the disk, and naked eye-specks at their base. And though such eye-specks are neither mentioned in Brandt's description of Staurophora, nor in the Eudora and Berenice of Peron, and though, in the two latter genera, no chymiferous tubes are described, which, at that time, were not known in any of the Medusæ, I have no doubt that both Eudora and Berenice belong also to the same family, Eudora forming the lowest stage in the development of a structure which is more developed in the others.

The figure of Peron exhibits the small central depression, with four radiating furrows, no doubt the analogues of the mouth of Staurophora, but differing in the deficiency of marginal folds and a prolonged membranous edge, while in Berenice a similar central cross is observed branching towards the margin, as in Forbes's genus Willsia, and, as the figure seems to indicate, provided in its peripheric ramifications with lobules, like those of the Western Staurophora; so that their natural relation cannot be mistaken. If all this be correct, we should at once strike out of our systems Eschscholtz's family Berenicidæ, as an artificial group, resting upon imperfect knowledge of the structure of the animals for which it was instituted; for it can now very properly be combined with that most natural group, first fully understood and characterized by Professor Edward Forbes, the naked-eyed Discophorous Medusæ. A comparison of an ideal vertical section of Staurophora (Plate VIII. Fig. 12) with those of the genera Hippocrene, Sarsia, and Tiaropsis (Fig. 3, 6, and 11) will satisfy the most skeptical of the close relation of these genera, and justify my assertion, that Staurophora is truly a member of the family of naked-eyed Medusæ. The letters indicating the different organs in this section correspond precisely to those indicating the homologous parts in the other genera; and need, therefore, no further explanation.

*** THE impossibility of adopting a systematic course in describing the Medusæ considered in the preceding pages will render their perusal somewhat difficult; and I deem it, therefore, necessary to indicate briefly the substance of the different paragraphs, in order to faciliate the reading of this paper, and to render references to it less troublesome.

times a quadrangular form, — An acquaintance with the morphology of the mouth of other Medusæ necessary to understand the generic characters of Staurophora, 306. — It has really a mouth, — I have seen it eating, 307. — *Staurophora laciniata*, the name of our species, — Organs of reproduction, — Color of this species, 308. — *Staurophora* belongs to the same family with *Thaumantias* and *Tiaropsis*, — *Eudora* and *Berenice* of Peron are also naked-eyed Medusæ, — the family *Berenicidæ* of Peron an artificial group, 309.

EXPLANATION OF THE PLATES.

Plate I. — Hippocrene superciliaris.

Figures of natural size and enlarged in different positions. Fig. 1, 2, 3, and 4, enlarged; Fig. 5 to 11, of natural size, slightly exaggerated. Compare page 257.

Fig. 1. Enlarged, seen in profile, slightly overhanging, with the tentacles raised, while in Fig. 5 they are spreading sideways and downwards.

Fig. 2. Seen from below, the mouth in the centre, and the branching fringes around it; the four sensitive bulbs, with the eye-specks, beyond which the tentacles are extended; the circular chymiferous tube and the nervous cord on its inner margin; the undulations produced by the inner muscles, and the inferior partition.

Fig. 3. Seen from above, the central digestive cavity being empty, and the four radiating chymiferous tubes very prominent. The chief difference between this figure and the preceding consists in the contracted state of the tentacles.

Fig. 4. In the same position as Fig. 3, only the tentacles are still more contracted, the central digestive cavity distended, and bunches of eggs are hanging around it.

Fig. 5. A specimen suspended motionless in the water, with its tentacles extended.

Fig. 6. The same, seen from above.

Fig. 7. Specimen contracted to the utmost, turned upside down, with its tentacles drawn in and the lower partition turned inwards.

Fig. 8. The same, seen in profile, somewhat turned sideways.

Fig. 9. A specimen contracting to push forwards, the tentacles following behind.

Fig. 10. A specimen in a similar state of contraction, moving sideways.

Fig. 11. A specimen at rest, as those in Fig. 1 and 5, but the tentacles drawn in.

Plate II.

This plate represents microscopic details of *Hippocrene superciliaris*.

Fig. 1. A tentacle raised upwards, with a dark eye-speck, *a*, at its base; *b*, an elongated portion of the tentacle; *c*, its middle in a more contracted state, and *d*, the tip. See page 270.

Fig. 2. The tip of the tentacle much enlarged; *a*, the larger inner cells; *b*, the smaller outer cells.

Fig. 3. A portion of the tentacle in an elongated state, much enlarged; *a*, the large inner cells; *b* and *c*, the smaller external ones.

Fig. 4. The tip of the tentacle, in a less elongated state than in Fig. 2; *a*, the large inner cells; *b*, the smaller external ones.

Fig. 5 and 6. Superficial epithelium. In Fig. 5, which is taken from the upper surface of the disk, the cells are very distinct and polygonal, some of them containing nuclei. In Fig. 6, which is taken from the lower margin, the cells are irregular, and their nuclei still more so.

Fig. 7. A part of the central digestive cavity, with the crosier-shaped radiating tube rising from one of its corners; *a*, the central cavity itself; *b*, the origin of the radiating tube; *c*, the arch which it forms above the digestive cavity. See page 261.

Fig. 8. The lower extremity of the radiating tube branching into the circular tube; *a*, the dilatation of the tube behind the sensitive bulb, from which the two branches of the circular tube, *b*, *b*, arise; *c*, the vertical part of the descending tube.

Fig. 9. A portion of the vertical tube; *a* indicating its cavity, and *b* its walls, which are equally distinct in Fig. 7 and 8.

Fig. 10. The upper arch of a radiating tube, in a position somewhat different from that in Fig. 7; in Fig. 7, the tube is in perfect profile, so that its inner cavity, *c*, contrasts closely with its walls, *b*; while, in Fig. 10, the tube is seen from above, *a* indicating its cavity, *b* and *c* its margins.

Fig. 11. A sensitive bulb in its normal connection with the vertical radiating tube, *e*, and the circular tube, *b*, *b*, much enlarged; *a* representing the nervous cord; *c*, the sensitive bulb; and *d*, the part of the tentacles with the eye-specks at their base. See page 268.

Fig. 12. The sensitive bulb seen from below, slightly enlarged.

Fig. 13. The sensitive bulb in a position similar to that of Fig. 11, but the tentacles hanging downwards; in such a position the connection of the radiating tube, *b*, with the circular tube, *a*, *a*, is very obvious. The eye-specks are indistinctly seen through the tentacles, *c*, *c*.

Fig. 14. The sensitive bulb in its connection with the lower partition, seen from below, the tentacles stretching horizontally; *a*, *a* represent the eye-specks; *b*, *b*, the tentacles slightly elongated, while their base, *c*, *c*, is considerably stretched; *d*, *d*, the ganglion of the bulb into which the nervous cord, *f*, *f*, penetrates; the dark cones arising from this ganglion point to the centres of the eye-specks; *c*, *c* being the circular chymiferous tube rising behind the bulb to unite with the vertical radiating tube; *g*, *g*, the muscular lower horizontal partition.

Fig. 15. The sensitive bulb raised and seen somewhat from the side, most of the tentacles raised upwards, while the lateral ones hang downwards. In this position, which the sensitive bulb assumes chiefly when the body is contracted, the bulb itself is folded into three lobes, one corresponding to the largest middle tentacle, the lateral lobes being formed by the tentacles of the two sides.

Fig. 16. A view similar to that of Fig. 14; *a* being the eye-specks; *b*, the circular tube; *c*, the nervous cord; *d*, the elongated tentacles; and *e*, the pigment cones of the ganglion.

Fig. 17 represents the lower margin of the body with two sensitive bulbs, one on the right, seen from without; one on the left, seen from within; *a* being the circular tube; *b*, the nervous cord; *c*, the lower muscular partition; *d*, *d*, the vertical radiating tubes; *f*, the inner vertical muscles; and *c*, the outer wall of the body.

Fig. 18. The central digestive cavity (see p. 260); *a* being the mouth shut; *b*, *b*, the transparent tissue forming the outer wall of this cavity; *c*, *c*, the main stems of the tentacles of the mouth; *d*, *d*, their terminal branches; *e*, *e*, the radiating tubes arising from the upper corners of the digestive cavity; *f*, the upper wall of the cavity; *g*, *g*, eggs imbedded in the surface of the digestive sac.

Fig. 19. The digestive cavity seen from above, with its four radiating tubes, *a*, *a*; *b* being a temporary swelling at the base of one of the radiating tubes; *c*, the centre of the cavity; *d*, *d*, its walls.

Fig. 20. A more enlarged view of the same, also seen from above; *a*, *a* being the radiating tubes, somewhat dilated at their base, *b*, *b*, containing granules which circulate to and fro from the central cavity into the radiating tubes; *c*, *c*, bunches of eggs upon the outer surface of the digestive sac.

Fig. 21. Mouth entirely open, seen from below, allowing a sight into the cavity of the digestive sac; *a*, *a* being the margin of the mouth; *b*, the main stem of the tentacles of one of its angles; *c*, *c*, the tips of the tentacles; *d*, the folds of the inner surface extending into the base of the radiating tubes; *e*, *e*, brown cells lining the inner surface of the cavity.

Fig. 22. The central digestive cavity in its most contracted state; *a*, *a* being its prominent angles, corresponding below to the four bunches of tentacles, and above to the base of the four radiating tubes; *b*, the central cavity reduced to the utmost by contraction; *c*, the folds between the prominent angles of the sac.

Fig. 23. The mouth, with its tentacles and bunches of eggs surrounding the central cavity, seen from below. The mouth, *a*, with its four folds, *c*, and its transparent margin, *b*, is figured as complete; but only two bunches of tentacles, *d*, *d*, and two bunches of eggs, *f*, *f*, are fully represented; *e*, *e* indicate the tips of the tentacles.

Fig. 24. A terminal branch of the tentacles, to show their irregular terminal divisions.

Fig. 25 represents such a branch more highly magnified, to show the large internal cells, *a*, *a*, and the coating of smaller cells, *b*, *b*, surrounding them; *c*, *c* being the terminal nettling cells.

Fig. 26 represents another terminal branch of tentacles less magnified, but showing, also, distinctly the large internal cells, *a*, and the transparent margin consisting of small cells, *b*, *b*, and the projecting nettling cells at the tip of the branches, *c*, *c*.

Fig. 27 represents a heap of such nettling cells.

Plate III.

This plate represents chiefly the muscles and nerves of *Hippocrene superciliaris*, all the muscles being printed blue.

Fig. 1 and 2 represent the superficial muscular bundles. See p. 275.

Fig. 1. *a*, *a*, *b*, *b*, *c*, *c*, bundles of vertical fibres ; *d*, *d*, connecting fibres between the upper and lower row of circular fibres ; *e*, *f*, main vertical external bundles ; *g*, *h*, secondary vertical bundles.

Fig. 2. *a*, *a*, circular fibres ; *b*, *b*, *c*, *c*, inner circular fibres ; *d*, *d*, main vertical bundles ; *e*, *e*, secondary vertical bundles ; *f*, *f*, muscular fibres of the lower partition.

Fig. 3 and 4 represent the inner muscles in two different views.

Fig. 3. *d*, *d*, main vertical bundles ; *e*, *e*, *f*, *f*, secondary vertical bundles ; *g*, *g*, bundles of the radiating tubes ; *i*, circular bundles.

Fig. 4. *b*, *b*, *c*, *c*, double outlines of the circular fibres ; *d*, *d*, main vertical bundles ; *e*, *e*, *f*, *f*, secondary vertical bundles ; *g*, *g*, bundles of the radiating tubes ; *h*, oblique fibres of the inner wall ; *i*, inner circular fibres ; *k*, circular fibres of the lower partition.

Fig. 5. Nervous system (see pp. 266 and 271) ; circular nervous cord below ; vertical threads following the radiating tubes ; upper cord between the curves of the radiating tubes, with plexuses under their arches, and descending threads midway between two radiating tubes ; all drawn in continuous dark lines.

Fig. 6. The plexuses under the arches of the radiating tubes.

Fig. 7. Seen from above, to contrast the outer and the inner systems of muscles ; *a*, *a*, the main vertical external bundles ; *b*, *c*, the double outline of the inner circular system ; *d*, the main inner vertical bundles ; *e*, *f*, the secondary inner vertical bundles ; *g*, the outer secondary vertical bundles ; *i*, the inner circular fibres.

Fig. 8. Also seen from above ; but the inner vertical bundles less projecting ; *a*, *a*, the outer main vertical bundles ; *b*, *b*, the outer secondary vertical bundles ; *d*, *d*, the main inner vertical bundles ; *i*, the circular inner bundles ; *k*, the circular bundles of the lower partition.

Fig. 9. Seen from above, the outer muscles being neglected ; *b*, *c*, the double outline of the inner circular bundles ; *d*, the main vertical inner bundles ; *e*, *f*, the secondary inner vertical bundles ; *i*, the inner circular bundles ; *k*, the lower partition ; *m*, the nervous cord ; *o*, the circular chymiferous tube.

Fig. 10 and 11. Contractile cells in different states of elongation, with their nuclei.

Fig. 12. Circular fibres of the lower partition.

Fig. 13. The cells of the main nervous cord.

Fig. 14. The lower partition, with a sensitive bulb ; *a*, sensitive bulb ; *b*, circular chymiferous tube ; *c*, nervous cord ; *d*, radiating fibres of the lower partition.

Fig. 15. Lower margin of the body ; *a*, lower partition ; *b*, nervous cord ; *c*, circular chymiferous tube ; *d*, vertical bundles of the outer wall.

Plate IV. — Sarsia mirabilis.

The figures of this plate represent this species in various natural attitudes, as it is observed swimming through the water, all the figures of natural size, excepting Fig. 1, 2, 3, and 4, which are enlarged to show more distinctly the different parts.

Fig. 1, 6, and 7. In attitudes of rest, when the gelatinous disk stands upright, and the four tentacles, stretched at right angles sideways from the lower margin, are bent suddenly, and hang loosely downwards.

Fig. 1. The large proboscis hangs down beyond the lower margin of the disk. The connection of the four radiating tubes with the circular tube of the lower margin and the hollow tentacles is plainly shown. In Fig. 7, two of the ten-

tacles are left out, to show more plainly this connection and the connection of the radiating tubes with the central cavity and the proboscis.

Fig. 2. As seen from above, the proboscis being retracted and coiled up within the main cavity of the disk. Here, also, the connection of all parts is plainly shown, and the outlines of the interior muscular system well defined.

Fig. 3. Seen from below, the tentacles being cut near their base.

Fig. 4. A six-rayed variety of the same species, seen from above, the tentacles being also cut near their base.

Fig. 5. A specimen in a state of contraction, seen obliquely from above, the tentacles contracting into irregular undulations.

Fig. 6. In a state of rest, the tentacles, however, to some extent contracted, and much shorter than in Fig. 8, 11, and 12, in which they are fully developed.

Fig. 7 gives a similar aspect, only the lower margin is contracted, while in Fig. 6 it is more expanded, so that in Fig. 6 the outline is hemispherical, and in Fig. 7 more globular.

Fig. 8. A specimen in a state of contraction of its lower marign, the gelatinous disk being elongated, and the animal, the tentacles of which are in the utmost state of elongation, turning upon itself, so that the tentacles are curved in graceful arches, and the proboscis drawn in.

Fig. 9. The body has assumed a more globular appearance, the tentacles are shortened, and the proboscis hangs out, the animal moving horizontally.

Fig. 10. The hemispherical disk is somewhat elongated, the proboscis hangs out, and the tentacles are still more shortened.

Fig. 11. The six-rayed variety swimming obliquely, with its tentacles fully developed and the proboscis curved inwards.

Fig. 12. Another specimen of the common variety swimming downwards, the tentacles elongated, but not in their utmost state of elongation, the proboscis also drawn in.

Plate V.

This plate represents structural details of *Sarsia mirabilis.*

Fig. 1, 2, 3, 4, 5, 6, and 11. The muscular system chiefly is represented, in blue color, but the radiating tubes and the circular tube, as well as the proboscis, are also more or less distinctly seen; in Fig. 1, 2, 3, 4, 5, and 6, the proboscis, however, is suppressed, not to crowd the figures.

Fig. 1. The inner muscular systems; *d, d* being the main vertical bundles; *c, c, f, f,* the secondary inner vertical bundles; *g, g,* the radiating tubes; and *i,* the circular inner bundles. In this state of contraction, in which the muscles are best seen, the circular tube of the lower margin appears as a quadrangular figure, contrasting most remarkably with its circular outline in a natural position, as shown in Fig. 11.

Fig. 2. The same, seen from below, so that the sensitive bulbs, with the eye-specks and tentacles, are well seen; *d, d* represent the main vertical inner bundles; *c, c, f, f,* the secondary muscular vertical bundles; *g, g,* the lower partition; *i, i,* the inner circular bundles; *l, l,* the tentacles; and *o, o,* the accessory bundles of the vertical tubes.

Fig. 3 shows the outer muscular system; *a, a* being the main external vertical bundles; *b, b,* the secondary external vertical bundles; all of which are united above by circular fibres, as are also the secondary bundles somewhat lower down; *g, g,* radiating tubes.

Fig. 4. The same muscles, from below; *a, a* being the main external vertical bundles; *b, b,* the secondary external vertical bundles; *g, g,* the lower partition; *l, l,* the tentacles.

Fig. 5. The same parts with the internal muscular systems in a specimen of the six-rayed variety; *d, d* being the main external bundles, confounded with the main internal bundles; *e* and *f,* the secondary internal bundles; *g, g,* the lower partition.

Fig. 6. The muscular system in the utmost state of contraction, so that the outline of the animal appears four-lobed and the inner main cavity eight-lobed; *d, d* being the main external bundles; *c, e, f, f,* the secondary internal bundles.

Fig. 7. The proboscis in its connection with the central digestive cavity, the radiating tubes, the circular tube, and the tentacle; *o* being the mouth; *a,* the lower part of the proboscis; *b,* its middle part covered with eggs; and *c,* its upper part; *d,* indicating the central digestive cavity; *e,* the radiating tubes; *f,* the sensitive bulb; and *i,* the eye-speck.

Fig. 8. The proboscis in another attitude; *o* being the mouth; *a, b, c, d,* corresponding to the same letters in Fig. 7; but in this figure there are no eggs; *e,* outer coat; *i,* inner coat.

Fig. 9 gives another view of the proboscis, the middle part of which is covered with eggs.

Fig. 10 represents the same apparatus in its utmost state of contraction, the letters *o*, *a*, *b*, *c*, *d* corresponding to the same letters in Fig. 7, 8, and 9. In this state of utmost contraction, the analogy of the proboscis and central digestive cavity of Hippocrene and other naked-eyed Medusæ is very obvious.

Fig. 11. A profile view, to illustrate chiefly the connection of the vertical tubes, *c*, *c*, with the proboscis, *o*, and the circular tube, *k*, below, and also the inner vertical and circular muscular bundles, *i*, *i*; *g*, *g*, lower partition; *l*, *l*, tentacles; *m*, *m*, eye-specks.

Fig. 12. A sensitive bulb, to show its connection with the circular tube, the vertical tube, and the tentacle; *a* being the circular tube; *b*, the vertical extremity of a radiating tube; *c*, the sensitive bulb; *d*, the eye-speck; and *e*, the base of a tentacle, upon the surface of which the clusters of nettling cells are distinctly seen.

Fig. 13 gives another view of the sensitive bulb, still more enlarged, and seen somewhat from the side; *a*, being the eye-speck; *b*, the hollow tentacle, in which granules are seen moving, as in the dilatation of the horizontal circular tube, *c*, and of the vertical radiating tube, *d*.

Fig. 14 gives a front view of the sensitive bulb; *a* being the vertical tube; *b*, the eye-speck; and *c*, the hollow tentacle, in which granules are also seen.

Fig. 15 represents the termination of a tentacle.

Fig. 16 represents its middle part in a state of contraction, so that the clusters of nettling cells do not appear distinctly.

Fig. 17. Part of a tentacle elongated to the utmost, when the nettling cells appear as isolated clusters.

Plate VI. — Tiaropsis diademéta.

Fig. 1 to 8 represent various views of the whole animal. Fig. 1, 2, 6, 7, 8, are of natural size. Fig. 3, 4, 5, considerably enlarged.

Fig. 1 represents it in its utmost state of lateral expansion.

Fig. 2. Somewhat contracted round the margin, so as to give it a hemispherical shape, as is also seen in Fig. 3 and 4.

Fig. 6. Contracted at some distance from the margin.

Fig. 7. The margin being highly contracted, giving it a more globular form.

Fig. 8. The contraction is carried so far as to give it an almost quadrangular radiated appearance.

Fig. 3, 4, 5, show the natural connection of all parts, seen in profile and from above; the radiating tubes are, however, somewhat differently placed in these three figures; they agree in Fig. 4 and 5; *a*, *a* represent the ovaries and spermaries; *b*, *b*, the radiating tubes; *c*, *c*, the large eye-specks; *e*, *e*, the central digestive cavity; and *i*, *i*, the fringes of the mouth.

Fig. 9 shows the connection between the central digestive cavity and the radiating tubes; *a* being the digestive sac; *b*, the fringes of the mouth; and *c*, the ovaries hanging around the radiating tubes.

Fig. 10 represents the mouth from below, the fringes being stretched sideways.

Fig. 11 represents the same as seen from above, so that the radiating tubes are plainly visible, and upon one ray the ovaries are drawn in their normal connection.

Fig. 12. The fringes of the mouth seen in profile.

Fig. 13 shows the connection of the circular chymiferous tube with the row of marginal tentacles, and one large eye-speck.

Fig. 14 represents the connection of the central digestive cavity with the radiating tubes, the circular tube, and the lower partition, from a young specimen. The number of tentacles between a large eye-speck and a radiating tube, and between two large eye-specks, is much smaller than in adult specimens, as may be seen upon comparison with the corresponding parts of a larger specimen, Fig. 15.

Fig. 16. The bases of some marginal tentacles, and a large eye-speck, in their connection with the circular tube and the lower margin of the gelatinous disk.

Fig. 17. One of the large eye-specks; *a* being its cluster of pigment-cells; *b*, the inner row of large transparent cells; and *c*, the outer row of transparent cells.

Fig. 18 represents the contractile cells of the lower partition.

Plate VII. — Staurophora laciniata.

Fig. 1 to 11 represent natural attitudes of this remarkable species, of natural size in Fig. 1 to 8, and somewhat enlarged in Fig. 9 to 11.

Fig. 1. From the side, somewhat contracted, in a state of onward movement, the marginal tentacles being drawn together and hanging backwards.

Fig. 2. From below, the margin being folded over like four lobes.

Fig. 3. A profile view, in an attitude in which the gelatinous disk is considerably raised.

Fig. 4. From above, the lower margin being contracted inwards.

Fig. 5. In the same position, the lower margin assuming a quadrangular outline.

Fig. 6. Swimming downwards, the margin contracted in a circular outline, and the tentacles drawn inwards.

Fig. 7. The lower margin is here stretched outwards in undulating lobes, seen from below.

Fig. 8. We have here a view from above, the whole animal assuming a more quadrangular shape.

Fig. 9. Magnified view of the animal seen from above, the curled tentacles stretching outwards. Small eye-specks are seen upon their swollen bases; but what is most prominent is the central cross formed by the radiating tubes, and the extensive fringes encircling the star-shaped mouth.

Fig. 10. A profile view of the same animal, the cross being placed so that two radiating tubes appear on the right, and two on the left.

Fig. 11. Another profile of the same, the radiating tubes being placed in a different position. Two small specimens of Sarsia are caught between the fringes of the mouth in two opposite parts of its extensive cross.

Fig. 12. The central space of the mouth with four radiating furrows encircled by membranous folds.

Fig. 13 shows in a profile view the origin of the closed radiating tubes, beyond the edge of the mouth, the folds of which hang below, and some eggs above.

Fig. 14. The same region seen from below, to show how the furrow of the mouth passes into a closed radiating tube.

Fig. 15. The central part of the mouth, with its four radiating furrows.

Fig. 16. The lower margin of the animal near a radiating tube, two tentacles hanging down, one curled upon itself, and the other cut at its extremity, and two equally cut near their base, lifted up to show that the eye-specks are upon the inner surface of the tentacles.

Plate VIII.

Ideal sections of all the genera illustrated in this paper. The illustrations in all the figures correspond to each other to facilitate comparisons.

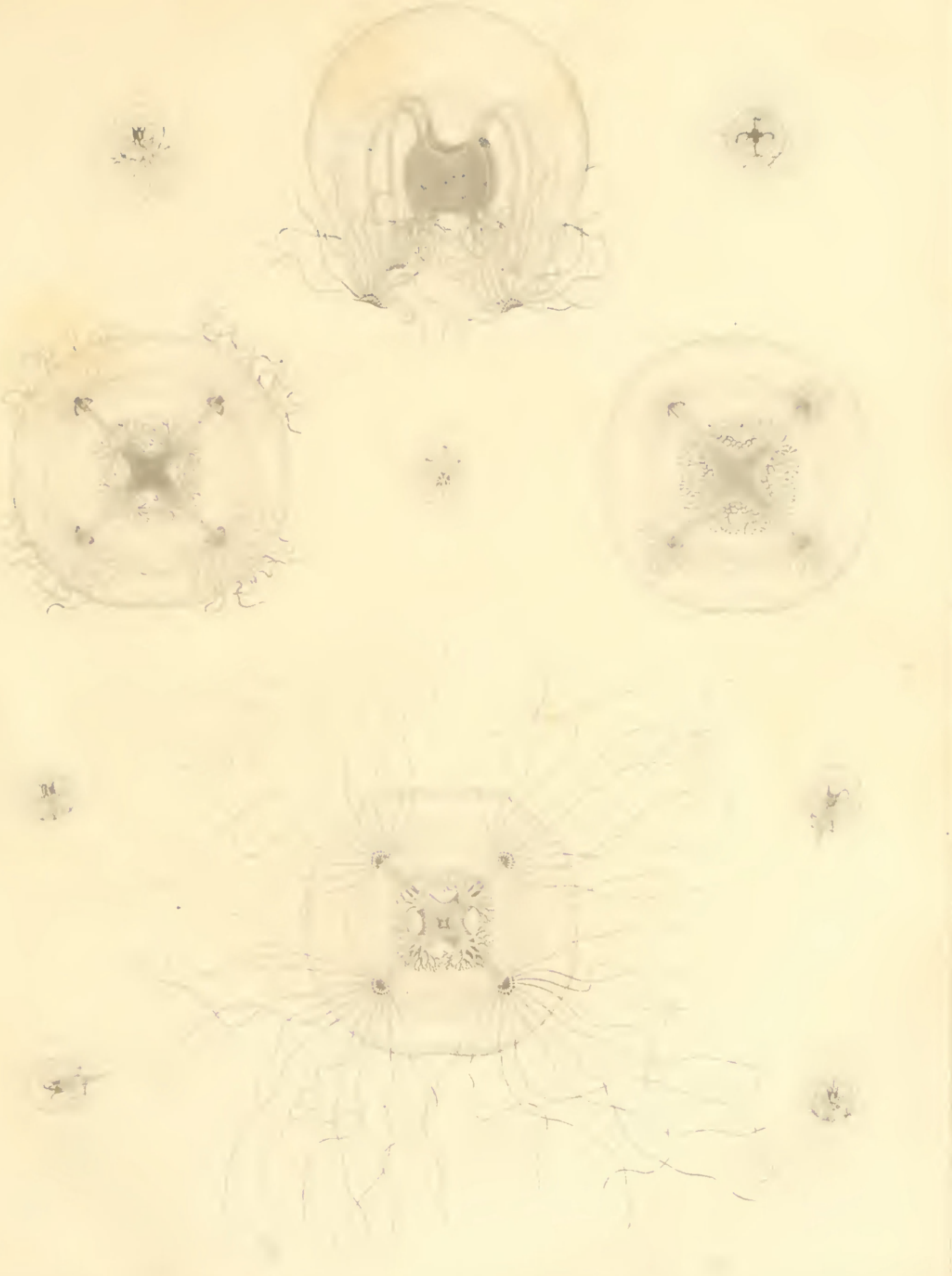
In Fig. 1 and 4, *a*, *a* represent the lower centre of the gelatinous disk; *b*, *b*, its main bulb; *c*, *c*, its lateral wall.

In Fig. 2, 3, 5, 6, 11, and 12, *a* indicates the main internal vertical bundles; *b*, the main external vertical bundles; *c*, the circular bundles; *d*, the nervous cord; *e*, the upper nervous cord; *g*, the nervous plexus; *i*, the circular tube; *h*, the tentacles; *k*, the lower partition; *t*, the vertical tubes.

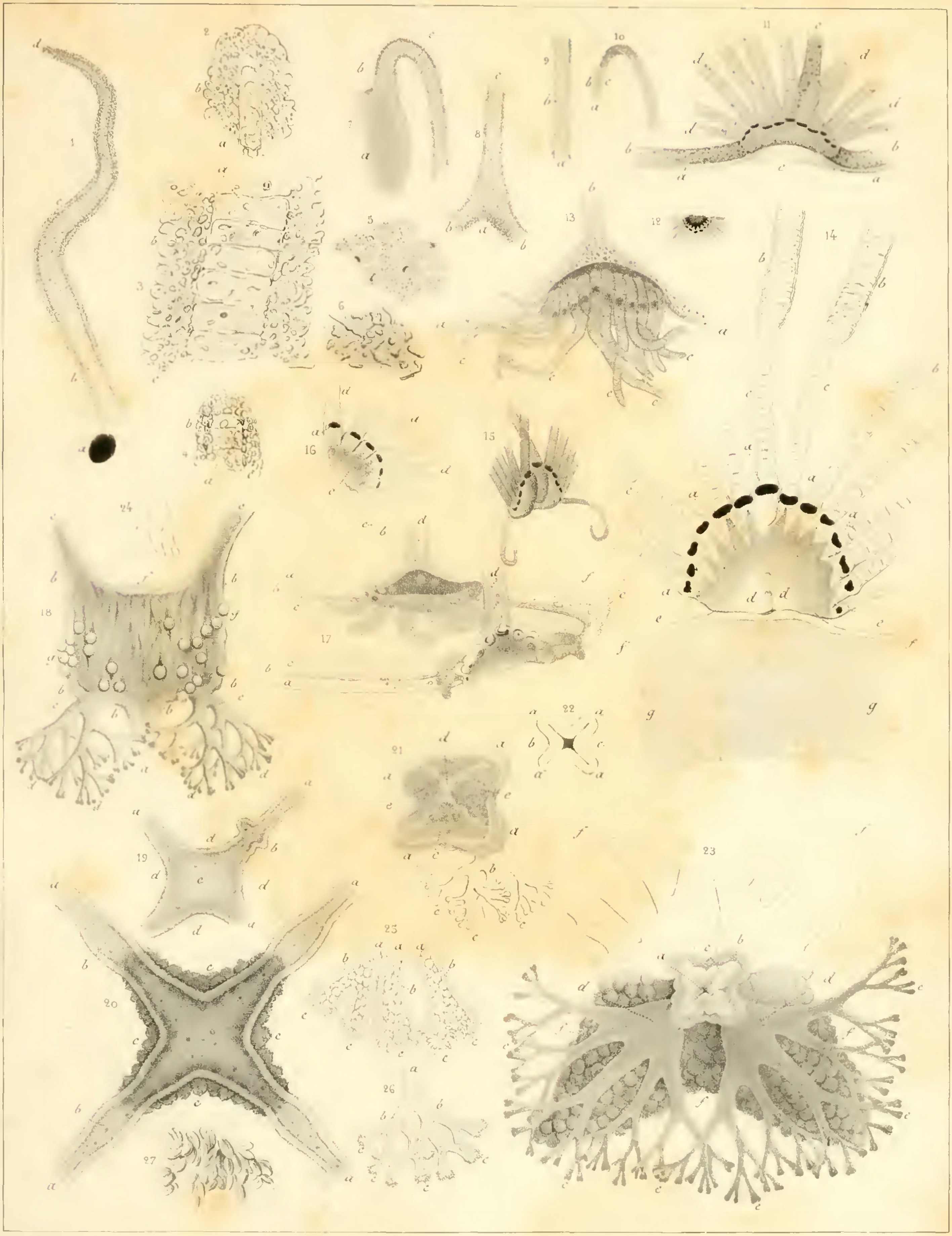
In Fig. 7 and 9, *a*, *a* indicate the inner circular muscles; *b*, *b*, the main external vertical muscles; *b′*, *b′*, the secondary vertical external muscles; *c*, *c*, the main inner vertical muscles; *c′*, *c′*, the secondary inner vertical muscles; *t*, *t*, the vertical tubes.

In Fig. 8 and 10, *a* indicates the lower partition; *b*, the nervous cord; *c*, the circular chymiferous tube; *d*, the sensitive bulb; *e*, the outer main vertical bundles; *e′*, the inner main vertical bundles; *t*, the radiating tubes.

Errata. — Page 285, line 10 from bottom, erase *f*, *f*. — P. 298, line 6 from bottom, read Fig. 6, instead of Fig. 5.



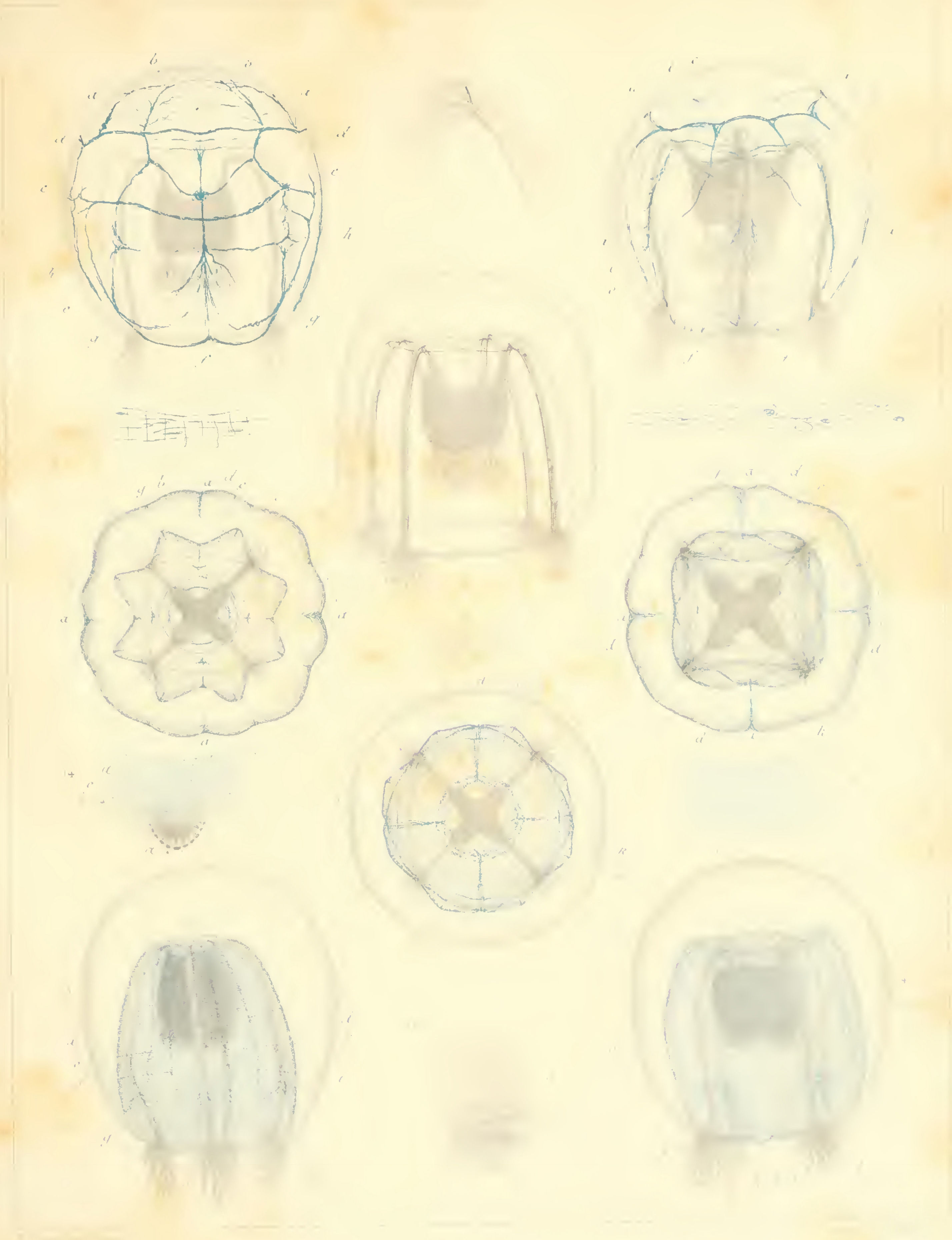
HIPPOCRENE SUPERCILIARIS Ag.



A. Sonrel, on stone from nat.

Tappan & Bradford's lith.

HIPPOCRENE SUPERCILIARIS Agass



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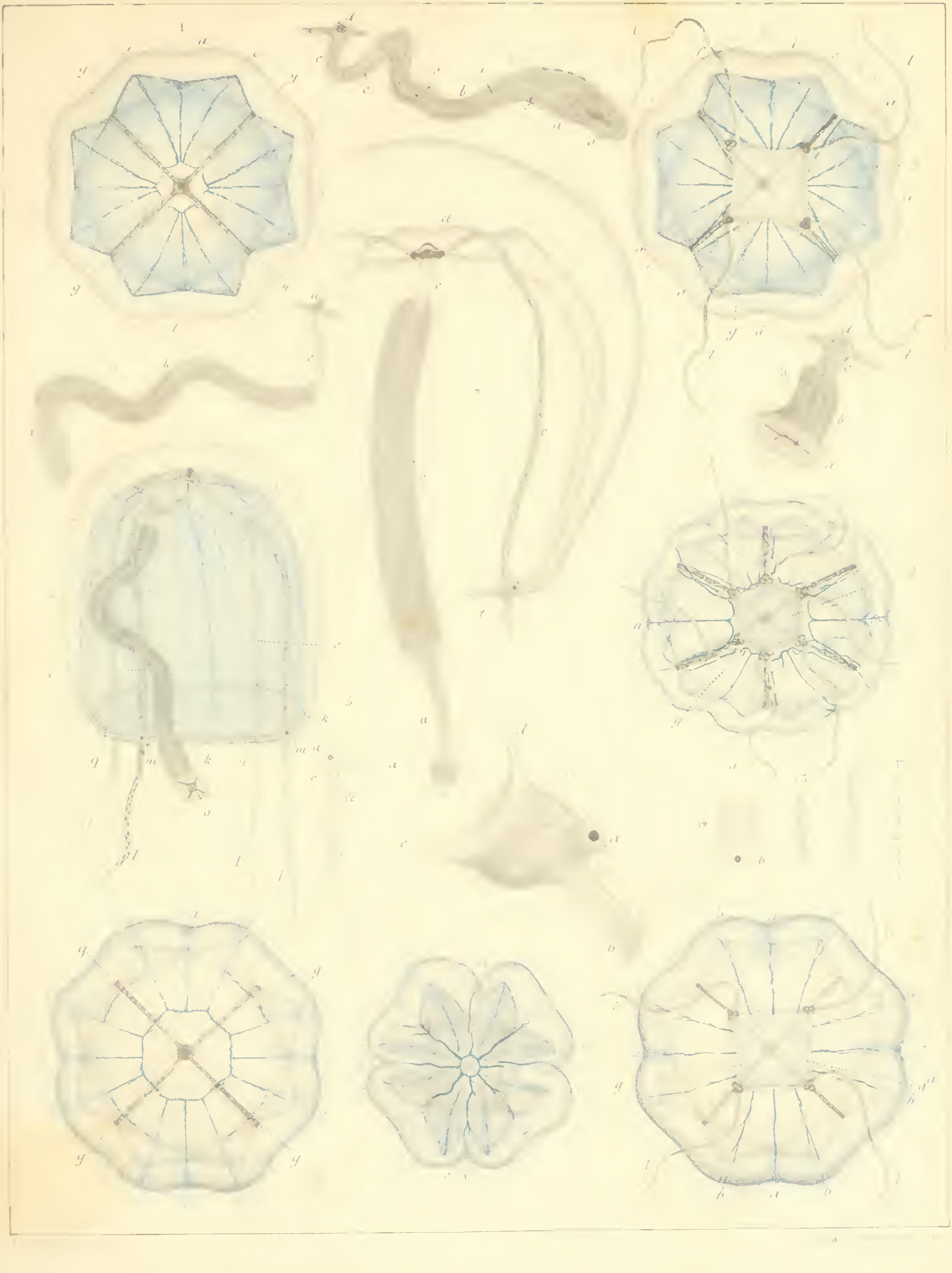
SARSIA MIRABILIS AGA



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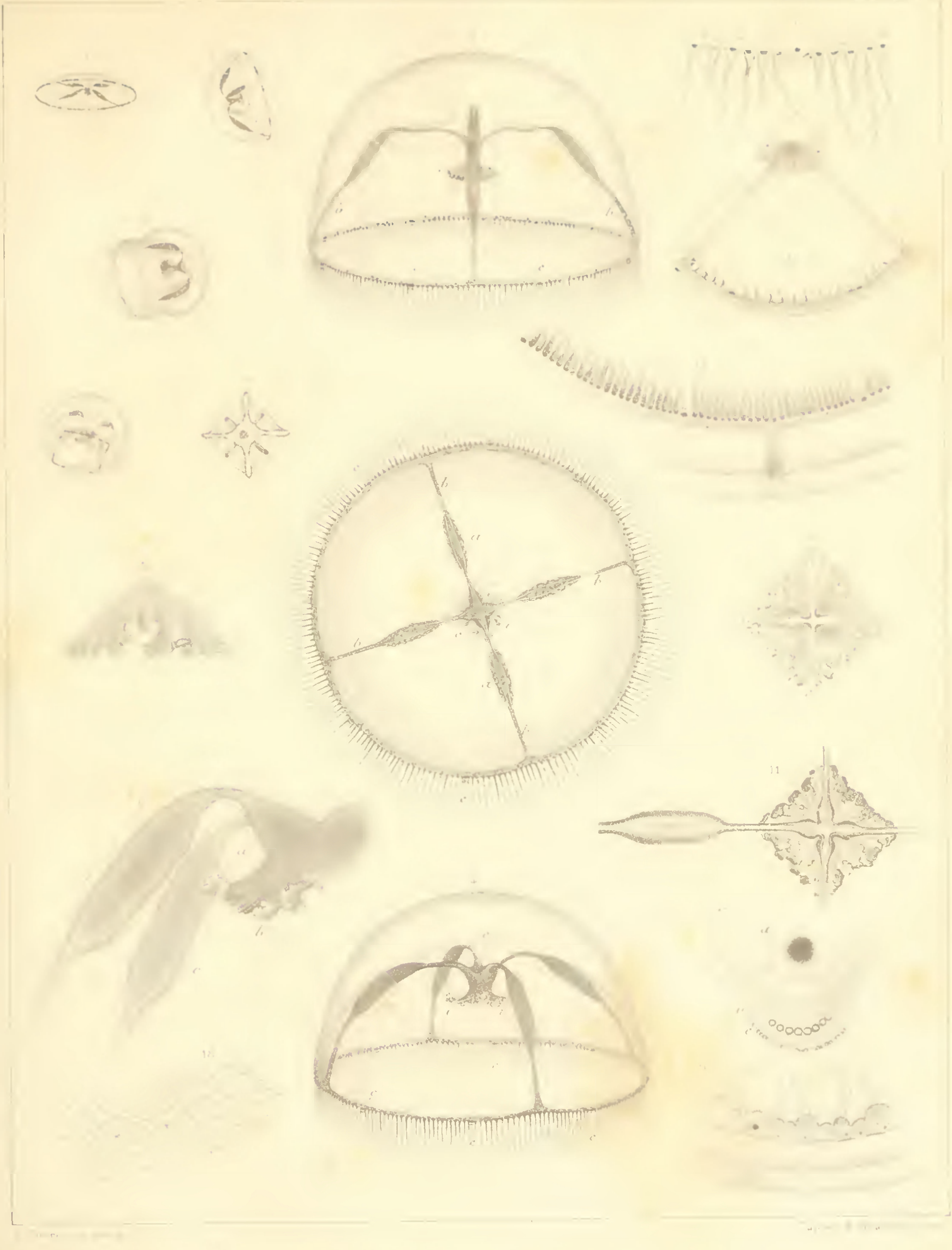
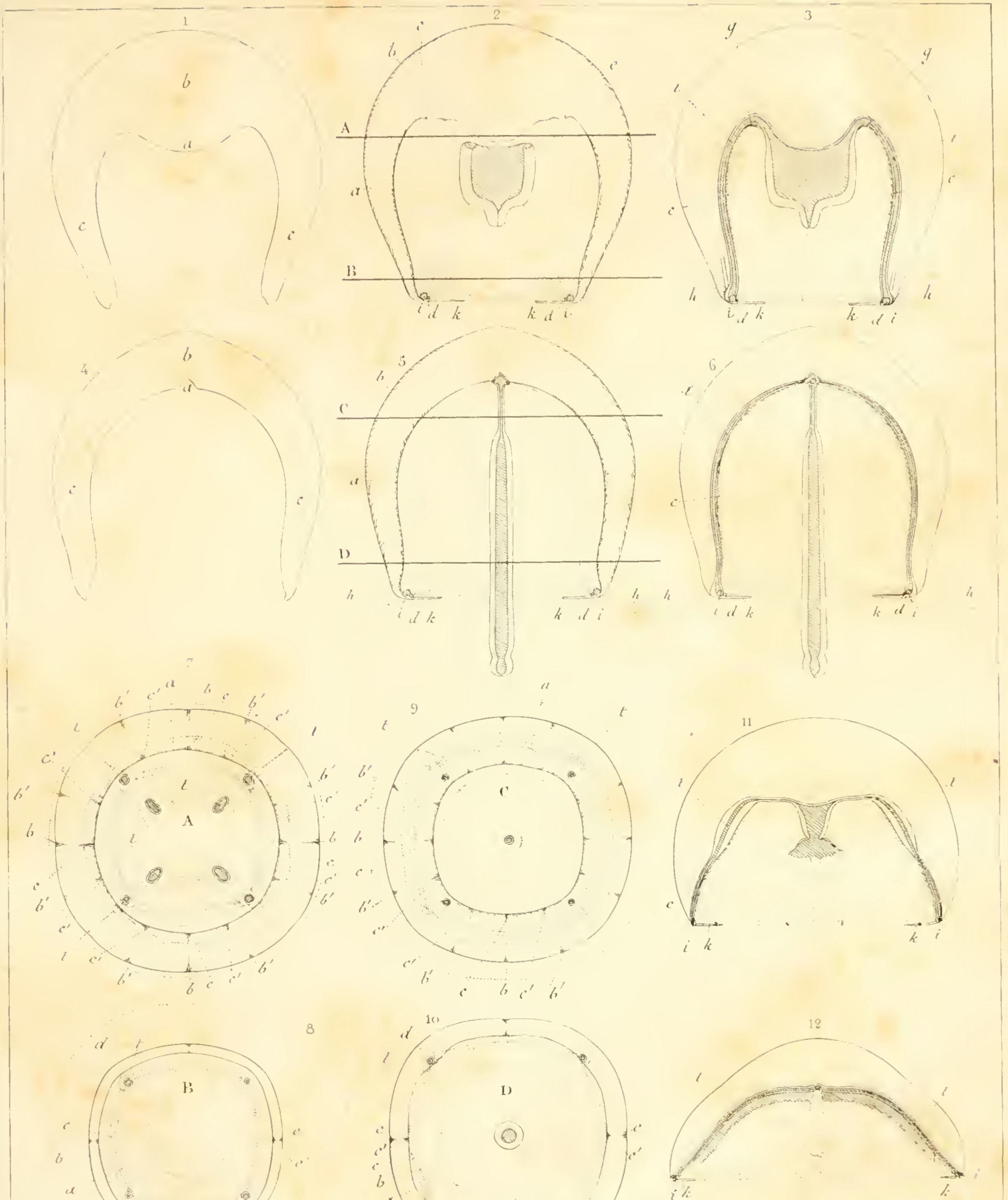


TIAROPSIS DIADEMATA Agass.

STAUROPHORA LACINIATA. Agass.



A. Sonrel on stone

Tappan & Bradford's Lith.y

IDEAL SECTIONS

X.

Contributions to the Natural History of the ACALEPHÆ *of North America.*

BY L. AGASSIZ.

PART II. — *On the Beroid Medusæ of the Shores of Massachusetts, in their Perfect State of Development.*

(*Communicated to the Academy, May 8th and May 29th,* 1849.)

PLEUROBRACHIA.

THE character of the Beroid Medusæ is entirely different from that of the Discophoræ. Both their form and organs of locomotion give them a different appearance. The common Discoid Medusæ, setting aside the various modifications arising from marked peculiarities of their outline, move like an umbrella, which, alternately opening and shutting, would make its way under water by means of such movements. It is by contraction of the body itself, — of its mass, or rather of the muscles which pervade that mass, — that motion is produced in those animals. Not so in the Beroid Medusæ, where the whole body, more or less spherical or ovate, compact or split at one end, is kept swimming by the flapping of innumerable small oars, arranged in vertical rows, like the ribs of an orange, upon the outer surface, along which horizontal combs of little fringes move with extraordinary rapidity, forming a sort of revolving wheel. These rows are generally eight in number, extending from one point to the opposite side, like the meridians of an artificial globe. But owing to the inequalities in the motions of their vertical flappers, and their almost circular arrangement around the more or less spherical body, these animals have a somewhat rotatory motion, unless the oars move on all sides with perfect steadiness and uniformity.

There can be scarcely any thing more beautiful to behold, than such a living transparent sphere sailing through the water, running one way or another, now slowly revolving upon itself, then assuming a straight course, or retrograding, advancing, and moving sideways in all directions with equal precision and rapidity, then stopping to pause, for a time almost immovable, with a slight waving of some of its vibrating fringes, which gentle motion easily counterbalances the difference in specific gravity between these animals and the water in which they live. So Pleurobrachia may appear at times, and so it even does appear when it moves in its state of contraction. But generally, when active, it hangs out a pair of most remarkable appendages, the structure and length and contractility of which are equally surprising, and exceed, in wonderful adaptation, all I have ever known among animal structures. Two apparently simple irregular, unequal threads will hang out from two opposite points on the sides of the sphere. Presently they will elongate, equal in length the diameter of the sphere, presently surpass it, increase to two, three, five, ten, twenty times the diameter of the body, and more and more; so much so, that it would seem as if these threads had the power of endless extension and development. But as they lengthen, they appear more complicated. From one of their sides other delicate threads shoot out like fringes, forming a row of beards, like those of the most elegant ostrich feather, and each of these threads itself elongates till it equals in length the diameter of the whole body, and bends in the most graceful curves. These two long streamers, stretching out in straight or undulating lines, sometimes parallel, then diverging, follow the motions of the main sphere, being carried on with it in all its movements. Upon considering this wonderful being, one is at a loss which most to admire, the elegance and complication of that structure, or the delicacy of the colors and hues, which, with the freshness of the morning dew upon the rose, shine from its whole surface. Like a planet round its sun, or, more exactly, like the comet with its magic tail, our little animal moves in its element, as those larger bodies revolve in space, but unlike them, and to our admiration, it moves freely in all directions; and nothing can be more attractive than to watch such a little living comet, as it darts with its tail in undetermined ways, and revolves upon itself, unfolding and bending its appendages with equal ease and elegance, at times allowing them to float for their whole length, at times shortening them in quick contractions, and causing them to disappear suddenly, then dropping them, as it were, from its surface, so that they seem to fall entirely away, till, lengthened to the utmost, they again follow the direction of the body to which they are attached, and with which the connection that regulates their movements seems as mysterious as the changes are extraordinary and unexpected. For hours and hours I have sat before them and watched their movements, and have never been tired of admiring their graceful undulations. And though I have found contractile fibres in these thin threads, showing that these movements are of a muscular nature, it is still a unique fact in the organization of animal bodies, that by means of muscular action parts may be elongated and contracted to such extraordinary and extensive limits. And what is so surprising is not so much the sudden powerful contraction which brings within the compact limits of a pin's head the whole mass of these tentacles, that a moment before were floating so elegantly through such a great extent in the water, as the relaxation, which takes place in an absolutely passive manner; for when watching them, we are suddenly struck with astonishment on finding that the tentacle which we expected to see drop to the bottom of the jar is still in organic connection with the body from which it hangs. Plate I. represents some few of the attitudes of Pleurobrachia in its various movements; but I cannot find words to describe all the beautiful changes which the parts thus in motion assume in different attitudes. At one moment, the threads, when contracted, seem nodose; next, when more elongated, these knots are stretched into the appearance of a spiral; next, the spiral, elongating, assumes the appearance of a straight or waving line. But it is especially in the successive appearances of the lateral fringes arising from the main thread, that the most extraordinary diversity is displayed. Not only are they stretched under all possible angles from the main stem, at times seeming perpendicular to it, or bent more or less in the same direction, and again as if combed into one mass; but a moment afterwards every thread seems to be curled or waving, the main thread being straight or undulating; then the shorter threads will be stretched straight for some distance, and then suddenly bent at various angles upon themselves, and perhaps repeat such zigzags several times, or they will be stretched in one direction, and bent at various angles in the plane of another direction; then they will be coiled up from the tip, and remain hanging like pearls suspended by a delicate thread to the main stem, or, like a broken whip, be bent in an acute angle upon themselves, with as stiff an appearance as if the whole were made up of wires; and, to complete the wonder, a part of the length of the main thread will assume one appearance, and another part another, and pass from one into the other in the quickest possible succession; so that I can truly say, I have not known in the animal kingdom an organism exhibiting more sudden changes, and presenting more diversified and beautiful images, the action, meanwhile, being produced in such a way as hardly to be understood. For when expanded, these threads resemble rather a delicate fabric spun with the finest spider's thread, at times brought close together, combed in one direction without entangling, next stretched apart, and preserving in this evolution the most perfect parallelism among themselves, and at no time, and under no circumstances, confusing the fringes of the two threads; — they may cross each other, they may be apparently entangled throughout their length, but let the animal suddenly contract, and all these innumerable interwoven fringes unfold, contract, and disappear, reduced, as it were, to one little drop of most elastic India-rubber. Week after week I have preserved these animals alive, and have never been tired of comparing again and again their changes in these thousandfold developments of their appendages. I have called together those who felt the slightest curiosity for such objects, to witness these phenomena, and have found them all interested to the utmost; and if I have any thing to regret, it is not the time lost in this contemplation, — for the more I became familiar with the sight, the more I was compelled to admire its beauty, and to contrast with the new forms presenting themselves before my eyes those different states with which I had been familiar before, — but it is the circumstance that the duration of their life is limited to a few months, and that I could not have a larger number of philosophic observers to contemplate with me these marvels, and that the time was too short to trace all the details of their structure microscopically; although I am aware that I have noticed many particulars which had been unnoticed before.

The chief difficulty in the comparative study of the different genera of this family arises from the circumstance, that they move permanently in different directions, some having the mouth naturally turned upwards, and others downwards; and that, from not having perceived this difference, the parts placed in opposite positions have been compared with each other in the different genera, which on that account require a complete revision of their characteristics.

The type under consideration, for which I retain the name of Pleurobrachia, as the most ancient applied to species of this particular conformation, is one of those which is deprived of peripheric lobes, that is to say, in which the gelatinous body is undivided, and the mouth constantly turned upwards or forwards when in motion; while the genus Bolina, to which I shall next call attention, is one of those in which one extremity of the sphere is split into two lobes, between which the mouth is situated, and in which this opening is almost constantly turned downwards when the animal is moving, though sometimes, when the animal is at rest, it turns in the opposite direction, opening widely its two lobes. It will be obvious how great mistakes may arise from comparing two animals constructed upon the same plan, but kept in a reversed position when contrasted. The difficulty of a thorough comparison of all the genera of this family is further increased by the circumstance, that genera without lobes or with slight indentations move naturally in the same position as Bolina; or in a position the inverse of that of Pleurobrachia. Such is the case, for instance, with Alcinoe, while Dellechiaja, with its very complicated lobes, moves in the position of Pleurobrachia.

Unhappily, all these animals have been figured without reference to the natural position in which they should be compared, and, no allusion to these prominent differences being made, it is hardly possible to reconcile the descriptions of one author with those of another.

The genus Pleurobrachia is limited to those species of Beroid Medusæ in which the body is nearly spherical or slightly elongated, the locomotive fringes extending from the margin of the mouth all round the sphere, in eight vertical rows, towards the opposite centre, where they approach very near to each other. This genus differs from Cydippe chiefly in the extensive development of the rows of locomotive fringes, which, in the latter, do not extend below two thirds of the whole height.

I know at present only two species of this genus sufficiently well characterized to be recognized as distinct species; one, the *Pleurobrachia* common on the northern shores of Europe, and the other that *Pileus* which I have observed on the eastern shores of the Northern United States, and for which I propose the name of *Pleurobrachia rhododactyla*, from its long, light rosy-colored tentacles.

Though almost spherical, this species is slightly compressed in the vertical plane of the two tentacles, so that one diameter, at right angles with the base of the tentacles, is somewhat shorter than that which would pass through their points of attachment.

As it is of great importance to the full understanding of the internal structure of this animal, and the correct appreciation of all its organs, to form a correct idea of their respective location, I feel compelled to enter into some tedious details respecting this slight variation from the spherical form; for though scarcely appreciable, it has a direct connection with the bearing of all the organs, which, upon close examination, are found to preserve throughout a constant relation to this apparently insignificant difference between the diameters; so much so, that these globular animals are truly bilateral in the arrangement of all their parts.

In the first place, the mouth is split transversely, and there is upon the opposite pole of the sphere an oblong, narrow, circumscribed area, placed also in the same direction, transversely to the longer diameter. So that the two tentacles with their bases are placed at right angles with the transverse split of the mouth and the opposite transverse area, the former being in the longer diameter, the mouth and the area in the shorter. The rows of movable fringes alternate, two and two, with these four radiating directions. So that there are four rows on one side of the plane passing through the tentacles, and four on the other; and also four on one side of the plane passing through the mouth and the opposite area, and four on the other, no one being placed either in the prolongation of the mouth, or in that of the bases of the tentacles (Plates III. and IV. Fig. 3 and 4).

Again, owing to the slight flatness of the body, the four rows of fringes have their upper and lower arms bending in a somewhat different manner, so that there are *two pairs perfectly parallel with each other along the prominent* side, inclosing the base of the tentacles, which are perfectly equal, and two other pairs along the flattened side, inclosing the prolongation of the angles of the mouth and the transverse projections of the opposite area. The consequence of this arrangement is, that each segment of the body has two unequal rows of locomotive fringes placed in a corresponding symmetrical manner opposite each other, side by side, or crosswise.

Having thus ascertained that the body of this animal is not truly circular or spherical, and that there is a medial axis, with reference to which the arrangement of parts is regulated, their four planes meeting at right angles, one of which passes through the longitudinal diameter of the mouth and the corresponding diameter of the opposite area, and another through the bases of the tentacles, which are prolonged into the interior of the body, the question at once arises how we should consider these rays; whether the mouth should be placed upwards or downwards, or whether it should be considered as the anterior extremity. As with the other Medusæ, whatever view we take of the subject, when we compare these animals with either Polypi or Echinoderms to ascertain their homologies, we must, as a matter of necessity, bring them all into the same respective position, and contrast the arrangement of their parts in their mutual correspondence. There is, therefore, no difficulty about this point, inasmuch as the mouth is made in every case the central point of comparison. But it has been ascertained that Polypi, though absolutely radiated animals, have in most of their types, if not in all, a rudimentary indication of a longitudinal axis in the oblong form of their mouth, which is the first indication in the animal kingdom of a bilateral symmetry, occurring even among the lowest Radiata, while in Echinoderms it rises higher and higher, and becomes so prominent in Spatangoids as to influence, not only the general form, but even the number and arrangement of the internal parts, and the length and special development of the external appendages and the ambulacral rows.

The class of Acalephæ, which is intermediate between those of Polypi and Echinoderms, holds in these respects also an intermediate position. Here we have a slightly compressed body and an oblong mouth. But the mouth opens in a direction transverse to the elongation of the body. The question therefore is, Does the mouth, with the plane which passes through the mouth and the opposite area, indicate the length of the axis of the body, and divide it into a right and left half, and are therefore the tentacles lateral appendages, one on the right side and the other on the left side, as we should consider them if we place the axis of the mouth in the same direction as the axis of the mouth in Polypi, or have we to consider the tentacles as arranged along the longitudinal axis, one on the anterior and the other on the posterior extremity? And in that case, is the split of the mouth rather the first indication of an upper and lower lip, — as we should consider them were we to compare the transverse position of the mouth with the position this opening assumes in the oblong symmetrical Echinoderms, in which the bilateral symmetry has been made prominent, — or have we to view also the indication of bilateral symmetry among Polypi as a tendency to such an arrangement between the two lips? I think I can be positive in the case of Polypi; for in Actinia, as well as in Astrangia, the oblong fold of the mouth is unequal in its two angles; and it were to suppose the right and left angle of the mouth to be unequal, and the upper and lower lip to be symmetrical, if we do not agree to consider this split as running in the longitudinal axis. And that it indicates really a longitudinal axis is shown by the circumstance, that fecal matters are discharged along the rounded angle of the oblong mouth, opposite to which there is in many Polypi a tentacle of a peculiar form. But this being the case, are there reasons to view Pleurobrachia in a different light? Are they really in their arrangement more nearly related to Echinoderms than to Polypi? I hardly believe it; for, as the mouth is transverse in so many Echini, their anterior and posterior extremities always differ more and more, in the same proportion that the bilateral symmetry is increased and made more prominent. It seems to me, therefore, more natural to compare Pleurobrachia with the other Radiata in a position in which the split of the mouth will indicate the antero-posterior diameter, even though the diameter considered as the transverse be thus greater than the longitudinal. This is, however, not the only instance of this case in the animal kingdom. In many Mollusca of the class Acephala, in the family of Cardiacea and Brachiopoda, we have numbers of genera and species in which the longitudinal axis is shorter than the transverse. And though the vertical rows of locomotive fringes may remind us of the ambulacra of Echinoderms, I still hold that such a position as I assign to them is in more direct accordance with the general progress of symmetry among Radiata than the reverse. The first tendency beyond the pure radiated arrangement which is introduced among them is to a symmetrical disposition and parity between right and left, even if the anterior and posterior extremities be marked only by this lateral symmetry, and are not made to differ from each other. Next, the two ends of the antero-posterior diameter are made to differ, and this we see introduced only among the higher Echinoderms. For, though bilateral symmetry can be recognized among star-fishes and Echini proper, their anterior row does not yet differ, and the first appearance of such a difference is introduced in the family of Clypeastri, and more developed in Spatangi. If, therefore, the Echinoderms, which as a whole rank above Medusæ, still retain so much of the radiated type, and the bilateral symmetry is developed in them among so many of their types solely in the perfect symmetry of right and left, without a difference between forwards and backwards, why should we expect this still earlier in the class of Acalephæ, especially when we are able to refer this type so easily to that of Polypi? I assume, therefore, decidedly, that the diameter which corresponds to the split of the mouth indicates the longitudinal axis, and shall, in the following pages, describe all parts with reference to this view. I thus consider the halves of the body which would be divided by a plane passing through the split of the mouth, and through the opposite oblong area, as the right and left halves of this animal, and therefore the tentacles as being placed right and left. But I must for the present leave it doubtful which is right and which is left; for the sides are so completely identical, the two angles of the mouth are so absolutely equal, the prominent projections of the opposite area so uniform, as to afford no indication upon this point. This is a very remarkable circumstance to occur in a class intermediate between two others, in which the anterior and posterior margin can be fully ascertained in the radiated arrangement, even in the Polypi, though they rank lower. Is there, however, not a compensation for this difference in the greater symmetry of the two sides, as there are only four rays upon which the development of the animal takes place in Medusæ, while in other Radiata the numbers are odd? But, again, among Polypi, in the family of Halcyonoids we have the tentacles strictly in pairs, and here, also, the oblong opening of the mouth passes between the four pairs of tentacles, in such a manner as to render the anterior and posterior extremities absolutely equal. In this respect, Alcyonium would agree with Pleurobrachia, and justify the position I have ascribed to its bilateral symmetry. In another great type of the animal kingdom, we have a similar, though inverse case, in the family of Brachiopods, in which the anterior and posterior extremities are perfectly symmetrical, but in which the right and left are widely different, and a pair of tentacles which, in some respects, might be compared to the tentacles of Pleurobrachia, placed forwards and backwards. So that, if we were justified in taking our standard of comparison from the arrangement of parts in another type, there could be no hesitation in considering the greater diameter of Pleurobrachia as the antero-posterior diameter, and one of the tentacles as the anterior and the other as the posterior, and the mouth as transverse. But here then right and left would remain doubtful. For the reason above alluded to, I have, therefore, no hesitation in tracing my comparisons through all the classes of Radiata, and introduce here the Brachiopods only that they may be remembered in this connection. The parts already mentioned in a general way are not the only ones which have reference to the bilateral arrangement. The tentacles arise in two sacs, extending inwards in a vertical direction towards the opposite side of the body, and reaching a point about as far below the higher centre of the animal as the point from which the tentacles issue is from the lower centre. These sacs are connected with another very large sac, giving out two wide hollow forks in opposite directions in the transverse diameter of the body, which branch at right angles parallel to the longitudinal diameter, and again give out each a branch at right angles, that is to say, parallel to the transverse diameter, thus forming the eight forks of eight hollow tubes, following for their whole length the inner surfaces of the eight vertical rows of locomotive fringes. The position of this complicated system, therefore, presents a regular symmetry, two main trunks penetrating symmetrically right and left from the central cavity, and branching in such a manner as to reach on each side with four arms the four vertical rows of locomotive fringes, and also to supply the sac from which the tentacles arise. This cavity is full of liquid, which is in constant movement by the agency of vibratory cilia, but also under the influence of a regular pulsation of the system in the two halves of the body, which alternate in their contraction and dilatation; so that at one time the fluid moves, to a considerable extent, from one side to the other, and next returns by the contraction of the opposite side through the same tube in the opposite direction, presenting something similar to what exists in Salpa, under circumstances differing considerably, however, as will be shown presently. The point to which I now wish especially to invite attention is the circumstance, that there is a large central cavity branching in a very symmetrical way in the right and left parts of the body, and undergoing a rhythmic movement of contraction and dilatation, alternating between the two sides. This cavity, which I shall call the chymiferous cavity, is not to be mistaken for the digestive cavity, which constitutes a sac within it hanging downwards from the mouth for about two thirds of the length of the animal, but which communicates with it in the same manner as the digestive cavity of Actinia communicates with the main cavity of the body. This chymiferous cavity finally has two apertures, by which it communicates with the surrounding water, and through which it discharges the refuse chyme. These apertures are placed in a symmetrical position on the two sides of the area opposite the mouth near its centre, obliquely opposite each other, so that one is in the anterior half upon one side of the body, the other in the posterior half upon the other side. These openings are generally shut, but they open at intervals to discharge the fecal matters, and are afterwards instantaneously shut again. It is very difficult to catch these movements, and even after I had seen them open and shut, I have frequently watched days for them without observing a repetition of the operation, which I have, however, seen so many times now, that I entertain no doubt respecting the position of these openings, and their natural function. Moreover, balls of fecal matters will almost constantly be seen floating with a rotating motion below these apertures.

This sketch gives as yet but a slight, very incomplete, and superficial idea of the remarkable complication of structure which may be observed in these animals. But such a preliminary illustration was necessary before undertaking a minute description of all parts and their natural relations, and before alluding to these details I would request the reader to bear the following points in mind; — that Pleurobrachia is not strictly spherical, nor even strictly circular, in its somewhat elongated form; that there is a longitudinal axis, which passes through the mouth and the area opposite; that the tentacles are in the longer axis, at right angles with the fissure of the mouth; that the digestive cavity hangs in a large circulatory cavity branching symmetrically in the right and left halves of the body, the branches, eight in number, reaching the eight vertical rows of locomotive fringes, two other branches providing the sacs from which the tentacles issue, and two others following the walls of the digestive cavity, these four latter rising from the main lateral stems of the central cavity along the transverse diameter, the forks supplying the locomotive fringes, on the contrary, branching first parallel to the longitudinal diameter, and emitting each another fork parallel to the transverse diameter; so that all parts have a precise geometrical relation to each other; and finally, that the right half of this system alternates in its contractions with the left half.

In the special investigation of the minute structure of the different systems of organs developed in these animals, it will be better to proceed in such an order as will assist us in the understanding of all the other systems, rather than upon a physiological principle.

Though the form is apparently well determined and regular, even superficial investigation will satisfy the observer that it is constantly changing within more extensive limits than the appearances would lead him to suspect. In the first place, the apparently spherical form is not only frequently altered into an ovate by the elongation of the mass, but it even assumes, at times, a form rather cylindrical than ovate, especially on the side of the mouth, by the extensive dilatation of this opening. The changes which the mouth assumes in its outlines are very extensive and frequent. When shut, and completely shut, it disappears almost entirely, and its position is scarcely marked by any thing more than an indistinct outline, towards which the upper ends of the rows of locomotive fringes converge. When half-way open, or while opening, it assumes an oval form, like a fissure across the body, which becomes gradually more and more elongated, then widens, and finally expands into an ample circular funnel-shaped depression. (Plate II. Fig. 1, 2, 5, 10, and 11; Plate III. Fig. 3; Plate IV. Fig. 3 and 5; Plate V. Fig. 3, 4, 5, and 6.) These movements are rather slow, and may be compared to the undulations of a slug or snail adapting its mouth to the form of its food. The changes in Pleurobrachia, however, do not seem to be called forth by the approach of food, but are rather the result of a natural disposition in this animal to be in an attitude ready to seize upon its prey. The movements are regulated by powerful bundles of muscular fibres arranged in a very regular manner. At first it would seem as if the whole mass of the body were equally gelatinous and transparent. But upon close examination, and even under a slight magnifying power, the large development of muscular fibres throughout these bodies is readily seen, and explains fully the easy movements of these animals, and the readiness with which they change their form.

The arrangement of these muscular fibres being most easily understood in their connection with the vertical rows of locomotive fringes, and the form and position of the circumscribed area opposite the mouth, I shall begin this illustration by some details upon that apparatus. The vertical rows of locomotive fringes (Plates I. to IV.) are entirely superficial. The fringes themselves (Plate II. Fig. 6) seem to be modified epithelial cells, for whenever, in the progress of decomposition, the epithelium is dissolved in the space between the fringes, it is easy to trace the decomposition of the tissue into this apparatus, even where the muscular fibres immediately below remain unaffected. Each vertical row consists of a great number of isolated, transverse, comb-like fringes, placed one above the other, and movable, either isolately, or in regular succession, or simultaneously. Each comb consists of a large number of thread-like bristles, slightly arched upwards and downwards, of which the middle ones are the longest, tapering gradually sideways, so that the combs are, properly speaking, crescent-shaped, with a straight base, the teeth or fringes of which are movable in quick vibrations, up and down, independently in each comb, and even independently to some degree in each portion of the same comb, as the middle fringes may be seen to move when the lateral are motionless, and *vice versâ*. But generally all the fringes of one comb act simultaneously; but the motion in all the many combs of one row is successive, so that, when the combs are very active, they seem like waves moving up and down in rapid succession along each vertical row, or like the waving spikes in a cornfield agitated by the wind. Again, the undulations of the different rows are independent; sometimes all the rows playing at the same time, at other times parts of the rows, or parts of each row, or parts of some rows, playing independently.

I have been unable to ascertain what is the structure of the fringes themselves. They seem to be stiff, and nevertheless they are too soft to be gathered for chemical analysis. They must be decidedly of a peculiar tissue, for their appearance is quite peculiar, and does not resemble that of the other tissues. The number of teeth or fringes in one of the larger combs may be about fifty, but they are not equally numerous through all the combs in one vertical row. The combs in the upper parts and in the lower parts of each row, nearer the mouth and the area opposite, are gradually shorter and shorter, and contain fewer and shorter fringes, the largest being about the middle of the vertical height. They terminate rather abruptly above, and at a greater distance from the centre than below, where they are naturally prolonged towards the central eye-speck; if the black tubercle in the centre of the circumscribed area opposite the mouth is really to be considered as an eye-speck.

The movements of these fringes seem at first to be identical with those of vibrating cilia; and one might be tempted to suppose that these locomotive fringes are formed by a row of compressed vibrating cells, arranged in such a manner as to bring their cilia in one row, and the cells themselves in such superposition above each other as to form vertical series. But the cilia or fringes are far larger than any vibrating cilia ever described, and their motion shows distinctly that they are under the voluntary control of the animal; for their movements are neither incessant nor constantly equal. They are at times accelerated or retarded, entirely stopped and resumed at shorter or longer intervals; so that the evidence of their voluntary movement is as full as can be, and, indeed, the structure which determines the movements is the same as in all cases of voluntary motion. A regular muscular apparatus can be traced along the base of each comb, muscular fibres forming a regular row above and below the base of the fringes, by the repeated contractions of which the fringes are moved up and down like flappers, in quick succession. But notwithstanding this muscular apparatus, which may be compared to a pennate muscle, the axis of which would constitute the point of insertion of the fringes, and thus control their movements up and down, it is hardly possible to refrain from the idea that these fringes are, after all, in some way or other, connected with vibratory cilia, — that they are vibratory cilia on a gigantic scale. And I do not see why there should be nowhere in the animal kingdom a transition between a particular arrangement of muscles moving independent appendages, and the structure of a ciliated cell regulating the motions of its own vibrating fringes. And if this view is natural, it will probably be found that the vibrating locomotive fringes of Pleurobrachia are, among the many complications of animal structure, precisely that step in their development where the complication of the isolated cilia has reached its extreme, and has been made the foundation of a higher stage of development, in which the parts, which, in the primitive cell, were simply structural complications, assume an independent existence, developed by the growth of new cells.

Fully to understand the character of the vertical rows of locomotive fringes, it should be borne in mind that they are connected for their whole length with vascular tubes following the same course (Plate III. Fig. 1 to 4), and which arise from the great central chymiferous cavity. This intimate connection leads naturally to the supposition that, besides their functions as locomotive organs, the vertical rows of fringes are in some way connected with respiratory functions, and that there is between these two systems the same natural physiological connection which exists in Echinoderms between the inner branchiæ and the ambulacral tubes; or in Worms, between the respiratory vesicles and the locomotive bristles.

The circulation of fluids, and the respiratory movements connected with this circulation, are almost throughout the animal kingdom in direct communication with locomotion, even in the higher animals. Among Polypi the dilatations and contractions of the body renew constantly the water which fills their cavity, and provide them with a fresh supply of aerated water. The same is the case among Medusæ. For even where there is no distinct individualized system of respiratory organs, it is obvious that a constant renewal of the surrounding medium, by means of which oxygenation takes place, is an essential condition for the maintenance of life; and where there are no special organs adapted to this purpose, the main movements of the body supply the deficiency. The water-pores in Echinoderms, through which their main cavity is constantly filled with fresh sea-water, undoubtedly perform a similar office. Again, among Mollusca, respiration and locomotion are still more intimately connected; but in a manner which differs decidedly from what we observe in higher animals. For there, by the dilatation and contraction of the respiratory cavities and the circulation of the blood through the respiratory organs, the body is amply supplied. But unless Acephala open their valves, unless they expand and contract alternately the whole body, the supply of fresh aerated water must be much less; and I doubt whether oysters and clams could be kept alive if their valves were shut constantly by pressure, and muscular motion, contraction and expansion of the large bundles which preside chiefly over locomotion, were prevented from coming into play in aid of the vibratory cilia of the mantle and gills. The manner in which the respiratory cavity is shut in so many Gasteropods, unless the fleshy parts are fully expanded, shows plainly that here again there is an intimate connection between respiratory movements and locomotion. In Cephalopoda this is still plainer, for, from the form of the respiratory cavities, from the disposition of the sacs in which the gills are placed, we can easily infer that the contractions and dilatations of these sacs, by which the water is renewed, must afford a material mechanical assistance in the progress of locomotion. Again, throughout the type of Articulata, this connection is most intimate, the respiratory organs being directly connected with the locomotive appendages, forming, indeed, parts of the various kinds of oars, fins, legs, and chewing appendages, by which the principal motions of the body are sustained. Not a joint can be moved here without influencing respiration, and, again, the expansion and contraction of the respiratory cavities, the filling of the respiratory vesicles, or the large circulatory sacs connected with the gills or fins, and the introduction of air into the tracheal tubes, must, in their turn, influence locomotion. And it were a subject well worthy of the attention of physiologists, to trace more minutely this double connection throughout the animal kingdom. Perhaps the type of Articulata is best adapted to make a beginning in these investigations. For among them, in the Crustacea, for instance, the chewing of the food itself is directly connected with the process of respiration. The motion of the jaws aids in forming and maintaining a regular current of water along the gills through the respiratory cavities, and even when otherwise not employed, the jaws are kept in motion in some degree to assist respiration. And it can hardly be doubted that the process of respiration also materially aids the insects in their flight, and that the state of expansion or contraction of the respiratory cavities is very different in the state of repose, or during flight. While watching locusts, I have often been struck with the state of wide expansion of their abdomen at the moment they start, and with the collapsed state of the whole body soon after they have alighted, which is even so great as to prevent their rising again immediately when chased.

Again, among Vertebrata, we find in fishes that the respiratory movements — the lifting and shutting of the operculum, the filling and emptying of the branchial cavity — aid the fish in slowly progressing; so much so, that when resting upon the bottom of a glass jar, apparently immovable, these animals are at times suddenly propelled forward under the action of a powerful occasional contraction of the branchial cavity, even if the ordinary locomotive organs, the tail and fins, remain absolutely quiet. How close a connection exists between locomotion and respiration in the Ichthyoid Batrachians, I have often had occasion to witness in a Proteus kept in confinement, in which the gills grew gradually paler and paler if the animal was absolutely motionless, but would instantly be filled with a large quantity of blood, and appear intensely red, after some violent motion. It might be objected, that this is a mere influence of locomotion upon circulation; but if there were not this natural disposition in all locomotion to influence the process of respiration more than any other system, why should not the blood, when such powerful motions take place, be accumulated in any other part of the body, — for instance, in the tail, which is the very cause of the motion, — rather than in the gills? In birds the extensive development of the lungs, the prolongation of air-sacs into the abdominal cavity, the wings, and the sternum, in those most remarkable for their power of flight, plainly indicate again the most strict connection between locomotion and respiration, though the nature of this connection be perhaps different from that which is observed in the lower classes. Nevertheless, it exists and can be traced to a very remarkable extent. We cannot fail to trace, also, similar relations among Mammalia, though here the influence between the two functions is not so direct. However, it must be acknowledged that it is extensive enough, when we consider how the aquatic types have to accommodate all their movements to the wants of the system for atmospheric air, and remain constantly within reach of the surface, in order to be able to return to it in a short time. How much the breathing is affected by violent movements is so well known to every one, that the existence of accessory muscles of respiration in Mammalia, the antagonism between the pectoral and abdominal muscles and the diaphragm, the use of belts by athletes in running, leaping, or wrestling, need hardly to be further mentioned as evidence of this mutual relation. Of course, in animals in which all the functions have reached a great degree of independence, they are no longer subservient to each other to such a degree as they were in the lower types; but even the unpleasant influence which excessive exercise of the locomotive power has upon respiration in the higher animals shows the intimate relation which prevails in the plan of organization.

One peculiarity which might be mentioned as indicating a further connection between locomotion and respiration, if the vertical rows of locomotive fringes are at all connected with respiration, is the circumstance that they serve, for their whole extent, as points of attachment for the muscular system, as we shall see presently when describing the contractile tissue. This connection, also, may remind us of the connection which exists in Vertebrata between the anterior limbs and the chest.

When examining the structure of the vertical rows of locomotive fringes, we encounter considerable difficulties, to which I would call special attention, for the benefit of those who may have an opportunity to repeat these investigations. The best way to study their peculiar structure is to cut off from the body a portion of the row, say three or four transverse combs, and to bring them separately under the microscope. But then the fringes lie flat, and the tips of each upper comb cover the bases of the lower, so that their insertion connot be well understood unless an upper comb be entirely removed, as in Plate II. Fig. 6. The connection of the chymiferous tubes with these vertical rows of locomotive fringes may be no obstacle in the way of their study in their living, active condition, for then they are so distended and so full of fluid as rather to facilitate their study, as they appear like a transparent basis through which the external appendages are examined with great advantage. But when pieces are separated from the body, the tubes collapse, and contract so much as to form a narrow erect hose about the middle of the vertical rows, which I had for a long time taken for a particular organ, until I ascertained, by repeated investigations, that it was the chymiferous tube empty and contracted. In Plate II. Fig. 6, the outlines of this chymiferous tube are drawn in two different stages of contraction, *a* and *a* representing its outline when half empty; *b*, *b*, when fully contracted. Again, vertical muscular fibres, and others crossing them at various angles, near the margin of the locomotive rows, may interfere with the study of their fringes, before one is fully acquainted with the subject. All these circumstances should be particularly kept in mind, when examining the muscular fibres of the base of the fringes, which act in moving them up and down, and which belong in their transverse rows to the isolated combs proper. These are best seen from the anterior surface of the rows, when a thin slice is cut in a vertical direction, and the combs themselves are placed upon the objective table with their base turned upwards. Finally, there are about this region other organs, the nature of which it has not been in my power to recognize, though they are constantly seen between the locomotive combs, alternating regularly with them, and placed about the third of their width. I allude to minute tubercles or ganglion-like swellings (Plate II. Fig. 6, 7, and 9, *o*, *o*), so small as to be, perhaps, simply isolated cells of a special character, but which, in the midst of the tissues, I have never been able fully to isolate. There are constantly two of them, or a pair, placed symmetrically, at equal distances between the single combs. Other swellings not so constant in their appearance occur in the middle line (*c*, *c*). These swellings seem to be united by a vertical thread; but this thread, as represented in Fig. 9, may be a rudiment or a fold of the contracted chymiferous tube, as I never could find it equal in appearance in two specimens. The swellings in this line may be particles of the harder contents of the chymiferous tubes, accumulating in the intervals of the combs, and forming little balls, when the tube is finally completely contracted. But whatever may be the real nature of these bodies, those which occur regularly in pairs are certainly of a different nature; for I have frequently seen distinct threads, or fibres, connected with them; sometimes, as in Fig. 6, arising at right angles with the vertical row, and extending sideways; at times diverging in four directions, as in Fig. 7; and at times the two kinds of fibres, though less regular, would appear in connection with them, as in Fig. 9. Whether these swellings, and the threads arising from them, are sensitive ganglia, sending out nervous threads, or whether their appearance, which is subject to so many irregularities, is the result of the contraction, and perhaps of the commencing decomposition, of numerous muscular fibres, lining the inner surface of the vertical rows of locomotive fringes, must remain doubtful. I should say, however, that I have never been able to discover these parts in the living animal, though they are readily found upon slices cut from it, often immediately after their removal. The appearance I noticed in the surface of the body between the combs, when kept apart, was always similar to what is represented in Fig. 8, where muscular fibres crossing each other in various directions were chiefly visible; and, below, were granules floating through the chymiferous tube, accumulating generally to a great amount in the centre (*a*), — owing, no doubt, to the greater diameter of the tube when seen in such a position, — and apparently fewer towards its margin (*b*), where the outline appears as a double line. But the great transparency of all these parts makes it exceedingly difficult to arrive at any precise conclusion, even with regard to their respective position.

With the spherical form characteristic of the family of Beroe, the general arrangement of the muscular bundles is also somewhat modified, though regulated by the same principle which prevails in the arrangement of the muscles in the Discoid Medusæ. Here, also, we have vertical bundles and circular ones, but, owing to the spherical form of the body, these extend all round the sphere from one pole to the other, like the meridians and parallels of an artificial globe, modified in the details of their arrangement by the form and extent of the mouth, by the disposition of the area opposite to it, and by the width and extent of the vertical rows of locomotive fringes, and also by the presence and position of a special cavity for the tentacles.

In Pleurobrachia proper, the vertical rows of muscular fibres are eight in number, alternating with the rows of locomotive fringes, beginning about the same height as those on the mouth side of the body, as is seen in Fig. 1, 2, 3, and 5, and extending to about the same distance from the opposite centre, where their arrangement, however, is considerably modified by the peculiar form of the circumscribed area of the anal end of the body. Six of these vertical bundles are nearly identical in their arrangement, but the two lateral bundles (Fig. 2), which extend in the direction of the axis of the tentacles, are somewhat modified by the opening from which the tentacles are issued, their fibres diverging and converging again, so as to have a direct influence upon the cavity in which the tentacles are contained.

Besides these main bundles of vertical fibres, we have as many more bundles alternating with them, which arise from the upper end of the vertical rows of locomotive fringes, and converge towards the margin of the mouth, combining their fibres more or less with those of the alternating bundles, and forming in their combination the powerful contractile apparatus which opens the mouth, and which, when this is shut, appears like a regular area of fibres radiating in all directions, as seen in Fig. 5 and 11, in which the mouth is absolutely shut, and contrasting most remarkably with that opening when spread to the utmost, as in Fig. 10. Similar fibres, though less regularly star-shaped, converge also from the lower extremity of the vertical rows of locomotive fringes towards the anal area (Fig. 4), but, from the peculiar form of the latter, and the curve of the chymiferous tubes around it, they have a somewhat peculiar arrangement.

The circular or parallel fibres or bundles of muscles (Fig. 1, 2, and 4) extend transversely from one row of the locomotive fringes to the other; and although transverse fibres pass under these rows, the circular muscular bundles cannot strictly be said to extend in unbroken continuity all round the sphere, in parallel, horizontal circles; for the chief bundles extend only from one row of vertical fringes to the next, their fibres being chiefly connected with the substance which gives attachment to the locomotive combs, and the number of fibres stretching across beneath being considerably reduced by the great development of the chymiferous tubes which follow the locomotive rows. Again, there are along these tubes, and under the locomotive combs, vertical fibres also, which interrupt the regular course of the circular ones, though the vertical fibres are here less powerful and less numerous than in the middle of the space between two locomotive rows, where the chief vertical bundles are accumulated. Towards the upper or mouth end of the body, however, above the vertical rows of locomotive fringes, the circular fibres seem to be circular all round the mouth (Fig. 10); or at least to form bundles which are crossed by the upper radiating muscular fibres, and interwoven with them, but not broken up into distinct segments of circular bundles. On the anal extremity of the body, the circular fibres are considerably reduced, though there are still some to be seen.

Considered isolately, the muscular bundles cannot be compared to muscles, as they exist in higher animals. They are, strictly speaking, isolated muscular fibres, loosely scattered, but more or less crowded together throughout the gelatinous mass, or upon some particular points of the body, and in particular directions presenting, when contracted, so much of a cellular appearance, as to be easily compared with elongated fusiform cells, assuming, indeed, frequently that appearance, and then passing again into a thread-like form, sometimes regularly swollen in the centre, at other times more towards one or the other extremity, and assuming, therefore, alternately a clavate, or fusiform, or filiform appearance, very much elongated, but nevertheless sufficiently characteristic to be compared to cells, their nucleus being often still distinguishable, but presenting no appearance whatever of striæ across the fibre. From their appearance, and from the change of their form during contraction, I can hardly doubt that they are hollow, and contain fluid. The chief difference in the arrangement of these fibres in Beroid and Discoid Medusæ consists in the circumstance, that in the former the muscular fibres seem to pervade the whole substance of the gelatinous matter which constitutes the main mass of the body; and, indeed, it seems to me that this gelatinous mass is, in its elementary structure, identical with the contractile tissue which pervades it, with only this difference, that the cells which contain the jelly are less contractile, and their liquid contents more consistent. But that even these parts are not altogether deprived of the power of contraction and dilatation would seem to be conclusively shown by the circumstance of the whole sphere in the same individual appearing at times larger than at others. And if this is so, we have here a body made up, to a very great extent, of the same elements as the foot of a mollusk, for instance, but differing in so far as that there the cells are metamorphosed into more perfect muscular fibres, while here the elements of the cells preserve more of the primitive character of such structures, though they undergo also a peculiar modification, inasmuch as we have here an elastic jelly interspread with contractile fibres.

I have been unable to distinguish in Pleurobrachia a special superficial system of vertical fibres distinct from those within; nor are the circular fibres so exclusively internal as in Discoid Medusæ, but interwoven with vertical fibres throughout the thickness of the walls of the body, though the vertical fibres are generally more numerous in the outer part of the main mass, and the circular fibres towards the inner part; as may be seen when examining the mouth in its contracted condition, when the radiating fibres alone are visible externally, as in Fig. 5 and 11, while the circular fibres are chiefly shown when the mouth is fully extended, as in Fig. 10. Though the contractile fibres maintain throughout the body chiefly these two directions, it were an exaggeration to imagine that the fibres all run strictly in either one or the other of these directions. On the contrary, in each bundle or row of either vertical or circular fibres, we find that their course diverges more or less from the prevailing direction, and that, for instance, towards the upper and lower summit of the body, about the height at which the vertical rows of locomotive fringes terminate on the two sides, the chief vertical bundles of muscular fibres diverge to form somewhat pennate bundles of fibres, as in Fig. 4 and 5, and that along the sides of the vertical rows of locomotive fringes the fibres also show a more or less pennate arrangement (Fig. 1 and 2). But the most particular disposition is in the two lateral bundles (Fig. 2 and 4), which above, towards the mouth, are at first similar to the other vertical bundles, but about the middle of their course diverge to inclose the bases of the tentacles, and form a sort of sphincter to enlarge and shut, in their relaxation and contraction, the opening of the cavity in which the tentacles are contained (Fig. 2, 3, and 4), *b* being a profile view of those bundles of fibres, *c* representing their termination upwards, and *d* their arrangement, when the aperture through which the tentacles issue is *fully* shut. The peculiar muscles which move the partition of the cavity of the tentacles will best be described with that system.

It has already been mentioned, that there is a wide cavity in the centre of the body of this animal, into which hangs the digestive cavity proper; but the natural relations of these parts are so difficult to appreciate, the ramifications of the cavities so complicated, and nevertheless so regular, and, again, so movable in their constant contractions and dilatations, that, with all the assistance of numerous drawings, as given in Plates III. and IV., I hardly expect to be able to give a correct idea of this apparatus, unless the reader is willing to consider attentively every point of the following description by itself, and to keep, at the same time, constantly in mind the relative connection of all parts, and their bearing upon the general disposition of the body.

In the first place, let it be remembered, and well understood, that the main cavity undergoes constant changes, as to its size and outlines, according to its temporary state of contraction and dilatation, and that both halves of the system of tubes, which arise from the main cavity and branch into the right and left halves of the body, alternate constantly in their contractions; so much so, that the one may be in the state of fullest expansion (Plate III. Fig. 2, *a*) when the other is in the most complete state of contraction; and, after a while, the reverse will take place, when *b* will be fully expanded, and *a* fully contracted. But in these alternate movements, there is a moment when both halves are in a state of apparent equilibrium, though one be in the process of emptying, and the other in the process of filling; but at the moment an equal amount of liquid has been pressed from that half which is contracting into that half which is filling, the symmetry is most complete. These alternate contractions are nearly as regular as the movements of diastole and systole of the heart, and take place by a constant balancing of the fluid alternately one way and the other. The difficulty of watching this singular circulation arises chiefly from the necessity of keeping the living animal in one and the same position in order fully to appreciate these movements, as the slightest obliquity will interfere with the perspective in such a manner as to make it altogether impossible to follow the natural movements. Again, unless the parts are placed in such a strictly identical position, those which are in pairs will create confusion, as they may come into various positions presenting apparently a close connection with parts to which they are not all related. Again, the peripheric tubes extending vertically over the whole surface cover so easily the origin of the different trunks arising from the main cavity, that it is indeed very perplexing to trace them all in their true connection. Add to these difficulties the circumstance, that the arrangement of parts, owing to the bilateral symmetry of the body, appears entirely different when viewed from the side, in profile, and in front, and it will be plain that, unless one keeps in mind two distinct images of the various connections of all these stems and their ramifications, in a front view and in a lateral view, combining them in thought with the rapidity with which such an animal may revolve upon itself, it will be impossible for him to trace for a moment its structure while alive, and he will only have constantly before his eyes the tantalizing image of a piece of machinery apparently very complicated, the structure of which he has to decipher while it is moving, but moving almost too fast to allow him to seize the connection of the different parts as they pass along, and which is not only deranged, but destroyed, the moment it is stopped. It was under such circumstances that I undertook to study the circulation of these animals, and though I succeeded in injecting indigo into their main cavity, and in having it circulate for hours at a time within the body of the same animal before it died, and though I was satisfied that not a particle of the colored liquid had passed into any part of the body into which the liquid before it was colored had not naturally free access, and though it was thus plain to me, that, even after being colored, the circulating fluid continued its normal course, I must say that I never investigated a more difficult subject, never had to devote so much time to the same point, and never taxed my patience to such an extent, as during these investigations. I insist upon these details, and state them at full length, because I know that I have now cleared up this subject, and may perhaps induce some other student to go through the long description I am about to give of it, since he can expect to have the matter settled for him. Let us proceed in this description as we should with a minute description of the ramifications of the blood-vessels of some highly organized animal. The difference which exists between the digestive cavity and the main cavity of the body will first engage our attention.

In a front view (Plate III. Fig. 2), when the two tentacles appear right and left, and the plane which passes through the longitudinal fissure of the mouth divides the body into halves, we have before us, on our right, one of those halves of the body, which alternates in its contractions with the other half on the left. It is according to this diameter that the antagonism between the two sides is introduced. Seen in this view, the digestive cavity appears throughout like a narrow fissure, *c*; but as it is wider in another direction, its outline, as seen in Fig. 1, is very broad. The fact is, that this cavity is a flattened sac, flat as long as it is not full of food, and the two surfaces of the flattened bag are pressed upon each other; so that when seen in profile, that is to say, facing the longitudinal diameter of the body, as in Fig. 2, it appears like a mere double skin, or a slit lined with a membrane; but when seen from its broadside, that is to say, facing the right or left side of the body, as in Fig. 1, it appears like a wide sac, and only during the process of digestion is it swollen into a more rounded sac or cylinder. The lower extremity of this sac is projected into the main cavity of the body, terminating there in a large opening, which, at the will of the animal, can be shut or opened; so that, like the stomach of Actinia, the central digestive cavity of Pleurobrachia communicates with the cavity below, or is shut up by itself. The difference between the two genera, however, consists in the limitation of the cavity of the body, which, as such, is circumscribed within the centre of the animal in Pleurobrachia, and sends off large trunks and tubes, branching diversely into its mass and along its surface, while in Actinia the whole body is hollow, and the stomach empties into that one large cavity.

The central cavity has two main stems, one extending into the right, and the other into the left half of the animal, as is seen in Plate III. Fig. 2, 3, and 4. It would seem from Fig. 2 as if the largest sac were hanging loosely in the central cavity; this is not the case, however, for the spaces communicating with the main cavity right and left of the digestive sac in this figure do not form a continuous cavity encircling the whole digestive sac, but are only two tubes, which arise from the main trunks of the central cavity, and follow the middle of the lateral surface of the compressed digestive sac, in an ascending course, up to the margin of the mouth, being simple narrow tubes, as Fig. 1 shows. Downwards, however, the main cavity extends in the form of a funnel, terminating with two holes near the centre of the area below. This funnel descends in the centre of the animal vertically, and lies, therefore, in its central axis. It assumes nearly the same appearance in whatever position it is seen, excepting, however, its termination below, which is furcate when seen from the side, as in Fig. 1, and simple when seen in front, as in Fig. 2. This part of the cavity and the main lateral trunks being, as it were, the centre of the circulation, we may view it as an axis which branches right and left, and which rises in the centre in two parallel forks up to the mouth; so that, when seen from the side, the double upper fork is seen as one, but the lower fork, which is at right angles with the former, is distinctly seen, and *vice versâ;* the main lateral stems and their ramifications present in the first position their broadside, and appear foreshortened in the other.

The two main lateral trunks (Fig. 2, *a*, *b*) branch off at right angles from the central cavity, and extend horizontally for some distance sideways, ascending slightly, changing their position, however, to some extent, according to the state of contraction or distention of the digestive cavity. Five branches arise on each side from these main trunks, or rather three, as we may view them. Perhaps some observers would say four, and really it is difficult not to exaggerate their connection, or to distinguish sufficiently between their branches. The fact is, that, before branching again, the two main trunks form, at their extremity, sideways, a sort of dilatation, from which arise two lateral branches extending horizontally backwards and forwards, and two close together, which may therefore be taken for one, ascend in a vertical direction upwards. Thus the main branches from the first trunks are either three or four, as we consider the vertical one as two parallel stems or only as one; but as the branches extending horizontally forwards and backwards give out not far from their origin two others, which extend also horizontally sideways, nearly at right angles with the former, and as all these branches originate so near the point where they communicate with the primitive main trunks, they may all with almost equal propriety be considered as arising directly from it. And if this view be taken, the main trunk may be said to have five branches, four horizontal ones, and one with two parallel tubes ascending vertically. The fact is, that the termination of the main trunk may contract or dilate in such a manner as to present alternately these different aspects. For instance, in its most contracted state, when seen from above, as in Fig. 3, there are distinctly six branches arising from the main horizontal trunk, the two vertical ones appearing like very short tubes, though they are actually as long as the others, because their whole length is foreshortened upon their origin, while the four horizontal branches are seen for their whole extent, two and two, however, united by their base; so that it may with equal propriety be said, that on the whole there are only four tubes, the two horizontal ones branching soon again into two; or, in the dilated state of the main trunk, when the branches arising from it are in a state of contraction, they all seem to originate from one common cavity, as represented in Fig. 4. Here the four horizontal tubes really seem to arise independently of each other, and the two vertical ones are brought so close together as to appear like one, making altogether five branches. In another state of contraction, the two vertical ones may seem united, and the two pairs of horizontal ones also, when there appear to be only three branches to the main trunk; and, unless the dilatations and contractions of these curious ramifications of the stems have been watched for a long time, these differences may remain unnoticed, but when fully understood, there is no contradiction in the apparently conflicting statements that there seem at times to be three, at times four, at times five, and at times even six branches to the main trunk. I should add, that, when seen from above or from below, unless the body is somewhat inclined, the vertical tubes altogether escape attention, and that the best position to ascertain their relative connection is a somewhat oblique external side view, as in Fig. 5. In Fig. 1, which represents the whole system in the same position, the view of the horizontal main trunk and its branches is somewhat confused, from the circumstance that it is projected upon the vertical central cavity, and the prolongation of that cavity upwards and downwards; but in Fig. 5 we have only the peripheric branches arising from the main trunk, that is to say, the portion seen to the right of Fig. 2, 3, and 4; while in Fig. 1 we have, besides that half, the central axis also, as likewise in Fig. 2.

I have described these peripheric branches as horizontal, and so they appear when seen from above or from below; but in a vertical position they are seen to be somewhat deviating from the same horizontal plane, the main branch reaching the periphery somewhat higher than the secondary branch, and the vertical branches inclining slightly outwards. These different branches have by no means the same functions, and are not connected with the same apparatus, the vertical branches extending into the peduncle or cavity from which the tentacles are protruded, while the horizontal branches communicate with vertical tubes, which follow the inner surface of the vertical rows of locomotive fringes for their whole extent.

As there are on each side four such horizontal branches and four vertical rows of fringed combs, there are also, in the whole, eight vertical superficial, chymiferous tubes, widest in the middle, and tapering upwards and downwards, which are in most strict communication with the central cavity through the four horizontal tubes, and the two main trunks, from which they themselves arise. The upper ends of the superficial vertical tubes, which I may call the ambulacral tubes, terminate apparently in a blind point; at least, I have been unable to trace a direct communication between any of them and the vertical tubes which follow the sides of the digestive cavity, though such a communication is seen in the genus Bolina, as I shall mention hereafter; it may, therefore, have escaped my attention in this genus. But whether there be such communication or not, the fluid circulated upwards through these tubes can be distinctly seen to retrace its way downwards; so that, in the ascending branch of the ambulacral tubes, the fluid injected through its horizontal branch is moved up and down alternately. This is also the case with the lower branch of the same vertical tubes, though the lower end tapers gradually into very slender tubes, which extend as far as the anal area, and unite there again with the central cavity. But this termination of the central tubes being too narrow to allow all the liquid injected into the larger stem to pass through, the liquid moves here also up and down. The movement, in reality, takes place in the following manner. Each of the eight horizontal tubes fills its vertical ambulacral branches, the fluid flowing, at the junction of the horizontal tube with the vertical stem, in two opposite directions, upwards and downwards. A small quantity passes through the narrow prolongation of the tubes below back into the main cavity; but the greater portion flows back during the contraction of the mass which has been moved upwards, is pressed into the horizontal tube, and returns to the centre of the movement to pass into the opposite side of the body. It may be, also, as mentioned above, that a small portion of the fluid passes through exceedingly minute tubes into the vertical tube of the stomach, and back into the central cavity, in the same manner as upon the anal extremity, as this is really the case in Bolina. However, this communication above and below is too narrow to establish a direct onward circulation; the liquid moves decidedly to and fro in the ambulacral tubes, and returns chiefly to the central cavity through the horizontal tube, and, what is still more interesting, the dilatation of the four tubes of one side alternates with the dilatation of the four tubes of the opposite side. Moreover, in each vertical ambulacral tube, the motion of the fluid is an undulatory one, owing to the alternate dilatation and contraction of the tube itself, as shown in Plate II. Fig. 6. The movement of the fluid in these tubes can be traced very satisfactorily, when following the course of the minute granules of colored matter suspended in the water after injection; but even in fresh specimens uninjected, the circulation can be tolerably well traced by watching the small particles of undigested food suspended in the mixture of water and chyme which is circulated throughout this system. As in Polypi, the whole mass of digested food, comminuted and reduced to a very uniform state, but in which the parts capable of being assimilated are still mixed with the refuse matter, is indiscriminately emptied into the main cavity of the body, and, with a certain quanity of water introduced in the same way into this cavity through the mouth, kept in a constant regular undulatory circulation throughout life. But as there is a double outlet through which this system can discharge its contents on the side of the anal area, the circulation is more or less active, all the tubes more or less turgescent, and the whole cavity more or less dilated, as the quantity of fluid in circulation is greater or less, which, to some degree, changes the relative position of the tubes and the central cavity. When very full, the wider central space is considerably raised, while in a state of relaxation it sinks lower down, nearer the anal extremity of the body. As long as the circulatory system is relaxed, the ambulacral tubes are very much contracted, their diameter is much less than under other circumstances, and by no means equals the width of the vertical rows of locomotive fringes; but when turgescent and full, they swell beyond their width. The force which acts in propelling the liquid through the system is not the same throughout. The alternate contractions of the two sides result from the muscular contractions of the two sides of the body regularly alternating; but the main cavity in its central parts is entirely lined with vibratory cilia, so that even when the body is perfectly at rest the fluid is maintained in a constant rotatory motion through their agency. I have repeatedly and distinctly seen these cilia playing round the lower opening of the digestive cavity, and upon the walls of the vertical, central, circulatory cavity, as well as upon the walls of the main horizontal stems, and upon the walls of the inferior vertical funnel, even as far as its two forks which diverge below. I have been unable, however, to discover similar cilia within the secondary horizontal tubes, or the vertical ambulacral tubes. I have also failed to discover them in the vertical tubes of the tentacular cavity, though they may exist there also. However, the contractions of this latter cavity by muscular power are so extensive, that the agency of vibratory cilia does not seem to be required to keep the fluid in motion in that part of the system. I should nevertheless add, that even the walls of the central cavity, where they are most distinctly lined with vibratory cilia, are also fibrous, and that these fibres are distinctly contractile, and the capacity of the cavity is not only increased and reduced in a passive manner by the accumulation of fluid or its expulsion, but also actively by the contraction and dilatation of the walls themselves. How the contents of this circular system are diffused into the substance of the body for nourishment is not very plain, as there are no capillaries, but everywhere broad tubes. From the structure of the whole mass, however, we may infer that assimilation takes place by a process of endosmosis and exosmosis. If this view is correct, we should consider the two ascending tubes upon the middle walls of the digestive cavity as the nourishing vessels of the stomach; the two main horizontal trunks as two respiratory vessels, branching into eight branchial vessels, which are the main trunks of the eight ambulacral vessels; and the vertical funnel below as a vascular cloaca, discharging its contents through two distinct apertures on the sides of the anal area near the lower centre.

The vertical tubes ascending into the sacs from which the tentacles issue seem to have a peculiar function, and to be directly connected with the movements of the tentacles, and these movements, again, to be connected with the alternate contraction of the two halves of the body, as there are no parts which undergo so extensive changes in their size, and in their state of contraction and dilatation, as these sacs. But their structure is so complicated as to require a minute description.

The two tentacles (Plate IV.), with their elongated cavity and the vertical tubes, which penetrate into the base of the sacs, constitute, indeed, most complicated pieces of machinery, in which hydrostatic power, elastic levers, and muscular action give rise to highly complicated combinations and most diversified phenomena.

In the first place, the cavity itself from which each of the two tentacles issues (Plate IV. Fig. 1, 2, and 5) is a wide, elongated, pear-shaped sac, the rounded extremity of which is turned upwards and bent obliquely outwards, so that its convexity is turned towards the centre, and its blind sac upwards and outwards, and its open lower extremity downwards and outwards. In this cavity, to which the surrounding water has free access through the lower opening, the tentacle, with its complicated base, is attached by a broader surface to the inner side of its upper part. And though the central cavity of the body communicates freely, through the vertical tubes of the main horizontal trunk, with the base and curved hook of the tentacular apparatus, there is no free passage from one of the cavities into the other. The fluid which is injected into the vertical tubes runs back through the same channels into the main trunk, and the water which washes the central cavity of the tentacular apparatus empties through the same lower opening by which it is introduced. In a state of dilatation water penetrates from without into the pear-shaped sac, and chyle is injected from within into the vertical tubes; and in a state of contraction the chymiferous tubes are emptied at the same time that the water is pressed out. (Plate IV. Fig. 1, 2, and 5.) During these alternate contractions and dilatations, the tentacle itself may be coiled up in the cavity, or drawn out at full length, though in the most dilated state the threads generally hang out. But there seems to be also an antagonism, in a middle state of dilatation, between the filling of the vertical chymiferous tubes and the protrusion of the tentacle, the motions of which depend partly upon the muscular action of the apparatus to which it is attached, and partly upon the state of dilatation of the tubes on the inner surface of its base. The dilatation and contraction of the tentacular cavities depend upon the contraction and dilatation of the vertical bundles of muscular fibres of the two lateral zones, and more especially of the sphincters around their lower extremities; the sphincter reducing the diameter of the cavity, and shutting its opening, while the vertical bundle shortens and widens the whole cavity.

To form a correct idea of the ever-changing state of these parts, it is necessary to keep in mind their form and structure, as well as their relative position. The base from which the tentacle arises (Plate IV. Fig. 5) is an oblong disk encircled by elastic springs around its sides, which are bent inwards at its upper end, and turned outwards and downwards in the form of a hook projecting outside. The flat base of this disk forms the inner partition of the cavity in its upper part, and the vertical chymiferous tubes, which penetrate into the base of the tentacular apparatus, rise close together and parallel to each other, at its lower margin diverging somewhat to reach the summit of the disk, but keeping nearly parallel between the marginal spring and its medial arch. From the summit the tubes also bend outwards and downwards, and terminate in blind sacs below the middle of the flat disk, so that, seen in profile, as in Plate III. Fig. 2, and Plate IV. Fig. 2, they appear like a tube terminating in a blind sac in the shape of a hook; but seen from the side of the animal, or by the broad surface of the disk, the curved termination of the tubes covers the upper portion of their ascending branches, as is seen in Fig. 5 of Plate III.

The action of the filling of this tube is, therefore, to project the whole apparatus into the tentacular cavity, and to stretch its upper hook outwards; the impulse to a retrograde movement of the fluid is probably derived from the elasticity of the spring encircling the flat disk, and especially from the pressure of its curved middle branch, aided perhaps by the action of a minute muscle, which descends obliquely from its lower extremity, and is attached to the inner wall. The figures of Plate IV. represent this apparatus seen in various positions, in order to make all its details as clear as possible; and in order fully to appreciate them, its position in the main cavity of the body should be contrasted with other figures illustrating the general arrangement of the circulatory tubes, as seen in Plate III., and especially the vertical tubes (Fig. 2 and 5) rising into the tentacular cavity. The base of this apparatus, being attached by its flat side to the inner wall of the cavity, appears in profile, in a front view of the animal, so that the flat disk is represented by a narrow margin, as in Fig. 2 of Plate IV., when its whole height is apparent. Seen from the sides of the animal, its width becomes distinct, and the elastic springs encircling its margin, and rising from the upper summit along the middle to form the external hook, are seen in face, as in Fig. 5 of Plate IV. Seen in half profile, or in a three-quarter view, both margins and hook become distinct, as in Fig. 1 of Plate IV.; and the tentacle which arises from the hook can be traced from its origin through the upper part of its course. In these three figures the whole height of the apparatus is equally apparent; but in Fig. 3 and 4 the cavity and apparatus are foreshortened, being seen from above in Fig. 3, and from below in Fig. 4. In Fig. 3 the curves of the springs in the upper margin are plainly visible, and the two tubes ascending along the inner wall appear like two holes. In Fig. 4 the origin of the tentacle is more particularly shown. In order to form a correct idea of the relations of the tentacle proper with the flat disk from which it arises, it is necessary to keep distinctly in view the arrangement of the springs encircling the disk. Whether these springs are a mere swollen margin of a membranous coat, or a fold of the inner wall of the cavity, or an organ of a peculiar tissue, I have not been able to ascertain. However, so much is certain, that along the vertical chymiferous tubes which arise towards the upper end of the tentacular cavity, there are on each side linear edges slightly swollen in their middle, and thinner below, but curved over the middle of the disk from above, where they unite; then, descending somewhat lower, they are detached from the outer surface of the disk, to meet on their lower margin a similar fold rising from below, and then hang downwards into the bottle-shaped cavity free, as an independent thread, surrounded as soon as it is free from the disk by numerous small elastic and contractile tentacles. The main thread, however, forms the stem of the tentacle, which is capable of an extraordinary development, and can also be contracted into a coiled bundle; so that, in the state of utmost contraction, it forms a sort of irregular ball of tuberculated appearance hanging from the hook, the tubercles of the surface being the lateral fringes; but when elongated, it is changed into a fine thread, and the fringes appear at intervals, either in a contracted or elongated form, assuming, in the former state, the appearance of little tubercles, which in their elongated condition are themselves like so many little threads. In Fig. 1 and 5 of Plate IV., as well as in Fig 5 of Plate III., the tentacle being in its state of elongation, the lateral threads are distant from each other. Their arrangement in this part of the tentacle, however, is not easily ascertained; but when expanded, or regularly contracted within moderate limits, we cannot fail to see that they all arise from one side of the main thread, and are throughout unilateral. The variations which they undergo in their various degrees of contraction and expansion having already been described, when speaking of the movements of these animals, I need not refer to the subject again. I shall only mention that they appear frequently coiled up like a corkscrew in a regular and more or less elongated spiral. But, strange to say, in this position, though placed upon the two sides of the body in a symmetrical position, the spiral is not antitropic, but coiled in the same direction on both sides of the body, though their bases and hooks, and, indeed, the whole upper part of their structure, show a regular antitropic arrangement, like all symmetrical parts throughout the animal kingdom. Here, however, I have constantly found the spirals of the threads, when coiled up, curved in the same direction, both of them turning to the left in an ascending direction, or to the right in the opposite direction. This is the more surprising, as in animals in which there are parts twisted upon the two sides of the body, those of the right side are curled in one direction, and those of the left side are curled in the opposite direction, thus establishing perfect symmetry; and this law of nature is imitated in architectural ornaments, to produce complete symmetry. Thus, the horns of cattle, sheep, and goats are twisted, the right to the left, and the left to the right, while in antelopes the direction is reversed, the right horn being twisted to the right, and the left horn to the left. The same is also the case with the bend of tusks in elephants and wild-boars, of the horns in deer, &c. Such an antagonism seems, therefore, not yet to prevail among Radiata, in which the anterior and posterior extremities have not become prominent.

Plate V. gives some further details of the structure of these tentacles. The main thread, a portion of which is represented in Fig. 1, consists of elongated muscular fibres, among which the nuclei of their primitive cells are sometimes still preserved, as seen in Fig. 8. The surface of the thread is covered by several layers of epithelial cells, among which, however, I have noticed no great differences in form and size, and I have also failed to discover lasso-cells among them, though these tentacles are endowed with an intense power of nettling, as they strike dead almost instantly any small Entomostraca which come within their reach.

As shown in Fig. 1, the lateral fringes arise uniformly from the same side, and where one is occasionally seen in a different position, it is easily ascertained that it is out of shape, owing to pressure when placed under the microscope. These lateral fringes have the same structure as the main thread, consisting of a bundle of elongated fibres in the middle surrounded by epithelial cells. The longitudinal fibres, however, extend into the main thread, where they appear like transverse fibres. There seem, however, to be no transverse fibres proper to any of the lateral fringes, nor even to the main thread, as, in every instance, I could trace those transverse fibres of the main thread into the centre of the lateral ones. The extension of the threads must, therefore, be of a more passive character, owing to the relaxation of the fibres, rather than produced by the contraction of annular fibres. The longitudinal fibres of the lateral fringes, however, may probably contribute in their contraction to the elongation of the main thread. This disposition explains very fully the slow elongation of the tentacles, in comparison with their quick and almost instantaneous contractions, and also the peculiar phenomenon attending this elongation, when, by starts, the main thread seems rather to be dropped from point to point to its fullest elongation, in a passive way, by the relaxation of the fibres. I am, however, at a loss to explain by their structure the elongation of the lateral threads at right angles with the main thread, when this is fully expanded, and their various dispositions, their frequent straight and apparently stiff elongation, and, still more, their sudden bending even in acute angles. These motions are so diversified, and sometimes so sudden, as to astonish even those familiar with the movements of these animals.

Having described above the position and changes of form of the digestive cavity, I have now only to add, that its inner surface has not throughout the same appearance, and is not uniformly flat. Near the aperture of the mouth, indeed, it is smooth, and when the mouth is fully expanded a broad funnel is opened leading directly into the digestive cavity, assuming, however, in its contractions very diversified forms, being at times perfectly circular, and at other times oblong, oval, or even angular. The anterior and posterior angles of the mouth form frequently a fold, as in Fig. 5 of Plate IV. or in Fig. 2 of Plate II., and in Fig. 3, 4, 5, and 6 of Plate V.; or it assumes a linear shape, as in Fig. 7 of the same plate, or a stellate form, as in Fig. 5 and 11, Plate II. The more the mouth is open and spread out, the more easy it is to follow to a considerable depth the tubes which rise vertically along the walls of the stomach, as seen in Fig. 3 of Plate III., where they are slightly bent sideways to show their origin from the main transverse trunk below. The walls of the stomach lower down present four folds, two of which are in the direction of the fissure of the mouth, along the anterior and posterior walls of the stomach, and two others at right angles with them along the middle of its broader wall, in the plane of the transverse axis of the body. These four folds are lined with brown cells, and constitute probably a rudimentary liver, or at least secreting cells aiding in the process of digestion. Towards the lower extremity of the digestive sac, between those prominent folds, the walls of the digestive cavity are lined with a vibrating epithelium, which is particularly active round the lower opening of the sac, when this is fully open. This vibrating epithelium is continued upon the outer surface of the sac, and lines also, as already mentioned, the inner central cavity into which the stomach thus projects. (Plate III. Fig. 6 and 7.)

If we now view this animal from the opposite side, we find a variety of organs, the structure of which is not easily understood. Considering them at first chiefly in their forms, it will be seen that there is an elongated area, well circumscribed in its outlines, extending in a longitudinal direction in the same plane as the mouth, with a black speck in its centre (Fig. 4 of Plates II., III., and IV.). Towards the centre of this area eight narrow tubes are seen diverging (Fig. 4 of Plates III. and IV.), and in an oblique position two indistinct projections may be observed near the margin of the area. What all these parts are is not easily ascertained, and it is still more difficult to determine their connection with other organs. The black speck in the centre (Plate V. Fig. 9 and 10) rests upon a tubercle within, which is itself encircled by a tube; but the narrow longitudinal area is a membrane with a well-circumscribed and somewhat prominent margin, covering a hollow space. The irregular transverse bulbs at the base of its anterior and posterior halves, near the black speck, are the swollen extremities of two branches of the medial vertical funnel. And if we start from these facts, we may perhaps throw some light upon the structure and functions of the whole apparatus. Let us, for this purpose, go back to a renewed consideration of the funnel itself. We have seen that it is simply a central, vertical, downward prolongation of the main central cavity, tapering gradually into a narrow neck (Plate III. Fig. 1 and 2); but before it reaches the lower surface, it enlarges again very suddenly, branching into two forks, which are themselves swollen into two irregular bulbs resting against the lower surface, one in front, and the other behind the central black speck, but both close to it, and partly encircling the tubercle upon which the black speck rests. These two bulbs are therefore simply dilatations of the forked lower extremity of the funnel, and we constantly see undigested matters accumulated in them and revolving in their cavity, with a tendency to accumulate laterally in an obliquely opposite direction in each of them. And at long intervals these prominent oblique angles will open (Plate V. Fig. 9), when the fecal matter within the bulbs is discharged, the aperture remaining for a longer or shorter time extended, and the vibrating cilia lining the inner surface playing very actively; but after a little while, these openings shut again.

These apertures might, therefore, be considered as a double anus; but I think it were a very injudicious comparison to homologize them with the anus of higher animals, for in this type the process of digestion and assimilation, and the circulation of the nutritive digested food, are carried on by means of apparatus widely different from what we observe in either Mollusca, Articulata, or Vertebrata. We have seen above, that the food is introduced into the digestive sac which hangs into the central cavity; that this sac opens freely into that cavity, and discharges there its contents, mixed with a large quantity of water; that this peculiar apparatus is subject to regular contractions, and circulates the fluid, with the nutritive parts suspended in it, into the various tubes branching through the whole system, and that gradually the refuse matters drop into the central vertical funnel, to be discharged below through the openings of the two hollow bulbs branching from its lower extremity. We have here, therefore, rather openings in the circulatory system than anal apertures, or rather, we have here an apparatus entirely different in its adaptation from either the alimentary canal or the circulatory system of higher animals, but constructed upon the same plan as similar apparatus in the class of Polypi and in other Medusæ, with only this difference, that in Polypi the digestive central sac empties its contents into a large cavity subdivided only with partitions, without definite circulatory tubes, but along which the fluids are nevertheless circulated up and down, and into the tentacles, and discharged either in a retrograde current through the stomach and mouth, or through the tentacles and lateral pores, when such exist. In Discoid Medusæ a similar circulation takes place, but without openings either in the periphery or opposite the mouth; at least not in the Naked-eyed Medusæ, though the fluid discharged from the digestive cavity is circulated through tubes into the periphery and around it, and the refuse matters, retracing their course, are emptied through the mouth. Whether any Medusæ have peripheric openings through which the refuse matters are discharged, as Ehrenberg maintains, I have been unable to ascertain. However this may be, so much is plain, — that, in Medusæ and Polypi, the whole digestive apparatus is in direct broad communication with the circulatory apparatus; that the fluid circulated is simply chyme mixed with water, carried through all parts, which either retraces its course or is discharged through particular openings of the circulatory apparatus; and that there is no continuous alimentary canal with an anterior and posterior opening, and no distinct circulatory system deriving its fluid through lymphatics from the alimentary cavity, but two closely connected systems, one presiding chiefly over the function of digestion, and the other circulating the whole mass of digested food, that is, chyme mixed with water. It will, therefore, be more proper to call the upper sac the digestive sac, the central cavity with its branching tubes the chymiferous sac, and the vessels chymiferous vessels; and to consider the circulation, not as a blood-circulation, but as a chymous circulation, and, in some degree, the centres of this circulation, which act in antagonism to each other by their alternate contractions, as a sort of chymiferous heart.

If we next consider the oblong area and its cavity, I am able to state that the hollow space below, which extends forwards and backwards from the two cloacal bulbs, is a direct prolongation of the cavity of the bulbs, lined equally with vibrating cilia, and in which the fluid accumulated in the bulbs moves also to and fro. (Plate V. Fig. 9.) The ridge which circumscribes the outline of these tubular sacs is very definite, and slightly prominent upon the surface, though smooth. But in some Beroid Medusæ, such as the true Beroe, this ridge is slightly fringed, and it may be that these fringes constitute rudimentary gills, and that the marked outline of the area in our Pleurobrachia is a rudimentary development of such fringes.

The narrow tubes alluded to above, as converging towards the centre of the circumscribed area, can be traced from the lower extremity of the vertical rows of locomotive fringes to the immediate vicinity of the black speck in the centre of the lower end of the body. These tubes are direct prolongations of the vertical or ambulacral chymiferous tubes, tapering gradually towards the lower extremity of the animal, and extending beyond the rows of fringes proper, but reduced in their diameter so much as to appear now as very slender tubes converging from the lower summit of the locomotive fringes to the centre of the lower surface of the animal. These tubes are eight in number, like the ambulacral tubes of which they are the continuation, and they converge two and two, being more closely brought together in pairs towards the black speck of the centre. (Plate V. Fig. 9.) In their respective position they differ somewhat; though rising from the four lateral ambulacra, they preserve a rather straight course from the summit of the rows of fringes to the centre of the area; the anterior and posterior ones, however, bend towards the elongated part of the area, and follow obliquely the course of its margin, thus contrasting in some degree with the lateral ones. How these tubes terminate I have not been able to ascertain in a direct manner, but am inclined to suppose that they empty into the lower bulbs of the funnel. The tubes are so fine, and the circulation beyond the main stem of the chymiferous system is so easily stopped as soon as the animal is not in the most favorable circumstances, and coarse materials in addition to pure homogeneous liquids are so unlikely to be forced into these narrow channels, as hardly to afford an opportunity to watch the direction of the current. Perhaps a comparison of the different arrangements of these tubes in various genera may lead to a more satisfactory result respecting this point of the circulation.

I am equally at a loss to account for the precise connection between all parts which may be seen around and above the central black speck (Plate V. Fig. 9 and 10). Even the nature of this organ is very problematical. In its appearance it resembles somewhat the marginal colored specks observed in Discoid Medusæ, and on that account has been viewed by some as an eye-speck; but by those who consider the so-called eye-specks of Medusæ as rudimentary auditory organs, it has been considered as an ear-speck. But notwithstanding the difference of opinion upon its functions, all naturalists who have examined Beroid Medusæ have identified the black speck, which occurs in a central position upon the extremity opposite the mouth, with similar specks occurring about the periphery of Discoid Medusæ. But in my opinion this comparison is not correct, and I am inclined to consider this organ or this speck as something similar to the central colored speck which occurs in the middle of the disk in Discoid Medusæ, and which is particularly distinct in young animals soon after they have been detached from the polyp-like stem upon which they grew, — as a remnant of the connection which exists between the mother stem and its progeny in those Medusæ which multiply by alternate generations. This homology cannot for the present be sustained by direct observation, since the embryology of Beroe is as yet entirely unknown. But I should not be at all surprised, if Beroe were found to be the free Medusa form of some Hydroid Polyp from which Medusa-buds have not yet been observed; for the analogy between this central speck and what might be called the remnant of an umbilical cord in Discoid Medusæ is far greater than may at first sight be supposed. Its position in the centre of the summit of the chymiferous cavity is identical with the position of a similar peduncle observed most easily in young Sarsiæ soon after their separation from their Corynoid stem. The circumstance, that at this extremity the chymiferous cavity has two openings in Beroid Medusæ, does not institute between them and the common Discoid type a greater difference than exists between the star-fishes with a central anus and those which are deprived of this aperture, and cannot on that account be considered as establishing a radical difference between the structure and arrangement of the main systems of the body in the two families. On the contrary, the circumstance, that here eight tubes, probably in connection with the central cavity, diverge towards the periphery, to extend vertically along its walls, and gradually to enlarge along the sides, establishes a close resemblance between the ambulacral tubes of Beroe and the vertical chymiferous tubes of the naked-eyed Discophoræ. Again, the circumstance of their uniting to form a circular tube around the periphery may be compared to the circumstance of the ambulacral tubes meeting in the peripheric horizontal tubes arising from the main central chymiferous cavity. There are differences in the number of parts, and slight differences in the manner in which they are carried out in their adaptation; but, on the whole, the relations between the mouth and digestive cavity proper, the central embryonic tubercle, and the chymiferous tubes, are essentially the same in the Beroid Medusæ and the Discophoræ.

There are some further complications in the Beroid, which are not yet carried out in the Discoid Medusæ. We shall see that Bolina in this respect is even still more complicated than Pleurobrachia. But this no more changes the fundamental relations, than the complicated ramifications of Astrophyton change the relations of that genus to Ophiura. They are essentially the same. Above the black eye-speck in the natural position of Pleurobrachia, or below it in those Beroid Medusæ in which the anal extremity of the animal is turned upwards, as in Bolina, there is a tubercle or ganglion-like mass of larger size than the black speck itself, consisting of heterogeneous elements, which seems to be encircled by a tube some way or other connected with the eight narrow converging ambulacral tubes, on the anterior and posterior side of which are seen four smaller tubercles or swellings, between which arise two threads rapidly diverging forward and backward, and extending into the circumscribed area. I can offer only suggestions respecting these parts, and must leave it for future investigations to decide what they are in reality. I am, however, inclined to suppose that the circle at the base of the ganglion is a vascular or chymiferous ring, answering to the ring observed above the proboscis in Sarsia, and I expect it will be proved that the eight narrow tubes connected with the ambulacral tubes arise from this circle, or empty into it. The four swellings in advance of and behind the tubercle are probably vascular dilatations of this ring, similar, in respect to the position where they occur, to the bulbs of the funnel and the two threads between them extending forwards and backwards are probably only outlines of the folds which form the circumscribed area. But there is no part of the structure of Pleurobrachia upon which I can be less positive than upon this point.

As for nerves which are said to arise from the ganglion connected with this black speck, I have been unable to make them out. I have seen numerous muscular or contractile fibres connected with the lower extremity of the chymiferous funnel; I have seen these fibres diverging from above the so-called ganglion, but have never been able to trace any one of them beyond the length which contractile fibres have: again, I have repeatedly seen these fibres in a state of contraction or relaxation, presenting so little regularity in their distribution, that for the present I think it were rather assuming to decide upon the disposition of the nervous system of Beroid Medusæ. I am even satisfied, from the descriptions published, that the eight converging narrow tubes, of which I find no mention in former authors, must have been probably mistaken for nervous threads by some; and when Professor Grant states that Beroe has eight nervous threads arising from a central ganglion, I suppose he alludes to the central black speck and its swollen base, and the eight narrow chymiferous tubes, the connection of which with the ambulacral tubes is so easily traced, though their central connection with the vertical funnel still remains doubtful. I do not, however, deny that this centre is a point where we have to look for at least one part of the nervous system, and the gelatinous lobes about the mouth for the other part, if there be really a distinct nervous system in Beroid, as in Discoid Medusæ. But, for my own part, I have failed in tracing it out; though I may add, that I am sufficiently acquainted with the structure of the region where it is said to have been observed, to doubt the accuracy of the statements which have been made about it, especially in the precision and distinctness with which it is mentioned. And I express these doubts, notwithstanding the doubts I have myself respecting the real nature of some organs around the central black speck, for the very reason that, after finding there more than has been seen and described, and various things which may answer the vague descriptions given, I do not in reality find what has been said to exist in that part of the animal. The points to which future investigations should be directed with particular care are especially the relation which the central black speck may have with the formation of Beroe as buds from Hydroid Polypi; next, the connection of the eight narrow tubes with the central funnel; and finally, a more thorough investigation of the tissues above the black speck and within the circumscribed area, and the apparent termination of the narrow tubes.

Although I have kept Beroe alive for a month during spring, I have never seen in any of them any thing like ovaries and spermaries, and have not even succeeded in ascertaining in what part of the body the organs of reproduction are developed. And I must confess that the descriptions published by various authors respecting the sexual apparatus of Beroe have not yet satisfied me of the correctness of their statements.

BOLINA.

The genus Bolina was established in 1833 by Mertens, from two species, one of which was observed in the Pacific, and the other in Behring's Straits. The genus is characterized in a remarkable paper on Beroid Medusæ, published in the Transactions of the Imperial Academy of Sciences, in St. Petersburg, in the second volume of the sixth series. It is considered as distinguished from other genera of that family by the great development of the mantle lobes, and by the circumstance of its eight rows of locomotive fringes not extending beyond the body itself; and though this characteristic is not strictly correct, in as far as I shall be able to show that the ambulacral rows are not strictly circumscribed within their apparent limits, the genus itself is a very natural group, which ought to be generally acknowledged. It is difficult to give a correct idea even of the forms of these animals, as they assume constantly different aspects in their various movements, and in the different attitudes in which they must be considered. Having had an opportunity to examine at repeated intervals, and for a longer time, a new species of that genus, which I have kept alive for months, I shall attempt to give a more complete idea of its remarkable structure, which may throw some new light upon the organization of the whole family, and also upon the natural relations which exist between its different genera. I saw this new animal for the first time, with Mrs. Arnold, of New Bedford, who had preserved it alive for my examination, in December, 1848. I myself afterwards found large numbers of specimens, during the months of March and April, and even as late as June, in various parts of Boston Bay. Dr. A. A. Gould, however, had already noticed this species as an inhabitant of the shores of Massachusetts, in his Report on the Invertebrated Animals of that State, where he considers it, however, as identical with the Alcinoe vermicularis of Europe. But a close examination has satisfied me that it is neither identical with that species, nor even belongs to the genus Alcinoe, but constitutes the first Atlantic representative of the genus Bolina.*

* It is a remarkable circumstance, that the Atlantic shores of America should furnish, in lower latitudes, a species of that genus so similar to that which occurs in Behring's Straits; but this is only one of the

There is a very marked difference between this species and Bolina elegans of Mertens, in the form of its lateral auricles and in its color, which is not rosy, as in the species from the Pacific, but of a milky bluish-white, as in Bolina septentrionalis, with which it agrees in the form of its auricles, differing from it, however, in the less limited development of its longitudinal diameter, in the greater approximation of the two auricles of each side, and in the greater width of the mantle lobes, for which reason I have called this species Bolina alata.

It is a most delicate, transparent, and diffluent animal; so soft, that it readily decomposes under the least unfavorable circumstances. The admixture of a small proportion of fresh water in the bowls in which I used to preserve them caused not only their immediate death, but their almost instantaneous decomposition. All my efforts at preserving specimens in Goadby's liquor have entirely failed, and when, under identical circumstances, I succeeded in keeping for a long time specimens of Pleurobrachia rhododactyla, I failed in preserving specimens of Bolina alata longer than twenty-four hours. Again, this species being by no means so common as the Pleurobrachia, with which it is found promiscuously, I had to contend with great difficulties in my investigations of its structure. I nevertheless succeeded several times in injecting it with indigo, and though the injection soon caused the death of the animal and its decomposition, I have been able to trace the circulation for a sufficient time to follow the full course of the fluids within the body throughout all its parts; and being already acquainted minutely with the arrangement of the chymiferous tubes in Pleurobrachia, I was fully prepared to institute between the two genera a minute comparison, to ascertain their differences, and to recognize the homology of their structure. I was even able to trace the connection of all the parts of the chymiferous system more fully in Bolina than in Pleurobrachia, and to ascertain connections between its central and peripheric tubes which I failed to perceive in Pleurobrachia, in which these connections may, however, be wanting to some extent, as has already been mentioned above, when describing Pleurobrachia rhododactyla.

In order fully to understand the structure of Bolina alata, and the relations of its various parts, it is necessary first to have a precise idea of its external form, which it is by no means easy to acquire, even after repeated investigations. Like Pleurobrachia, the body of Bolina is more or less ovate, but in an inverse direction; for its greater diameter follows the plane of the corresponding organs in such a connection as to show

many instances which show that species on the opposite shores of this continent are adapted to the difference which exists in the climatic condition, and the different course of the isothermal lines on the eastern and western sides of the Old and New Worlds.

that the antero-posterior diameter is the longer, while it is the shorter in Pleurobrachia, and *vice versâ*, that the transverse diameter is the shorter, while it is the greater in Pleurobrachia. This inverse agreement between the natural relations of organs and external form is most satisfactorily ascertained, upon comparing the position and direction of the circumscribed area and of the tentacles, and we shall see hereafter that in every respect the proportions of the body with reference to their longitudinal and transverse development are reversed in the two genera. Before this contrast had been established, I was unable to trace the homology of parts between the two genera. Indeed, taking the general form as a guide, I began with comparing the two animals in a position in which I undertook to place their prominent diameters in the same relation, and thus arrived at the conclusion, that the tentacles, which are far less developed in Bolina, and issue from the margin of the mouth itself, were organs differing from the tentacles of Pleurobrachia, which I considered as a system entirely peculiar to that type of Beroe, while the tentacles of the type of Bolina appeared to me as a sort of fringes of the mouth. But the moment I placed the diameters of the two bodies in a position inverse to their length, all parts being placed in the same natural relation as far as they correspond by structure, their perfect homology throughout the system was at once established. And not only the correspondence and antagonism between the anal area and the tentacles, but also the minor details in the ramifications of the chymiferous system, agreed in every respect. The difficulty under which I had labored was precisely that of an artist attempting in a family picture to bring out the resemblance between two kindred faces, while contemplating one individual in profile, and the other in a front view, but believing their position to be the same. With this inverse relation between the homologous parts considered in their reference to form in the two genera Bolina and Pleurobrachia, there is a corresponding opposition between the natural positions of the two animals in the surrounding media. Pleurobrachia, as I have stated, swims naturally with the mouth upwards or forwards, and the anal area downwards or backwards; in Bolina the animal moves with the mouth downwards and the anal area upwards.

The position of the tentacles, their natural relations to the body when in motion, and the direction of the aperture through which they issue, were the chief sources of error which led me first to consider them as different apparatus; for in Pleurobrachia (Plate I.) they are turned downwards towards the anal apertures, while in Bolina (Plate VI.) they are turned downwards towards the oral aperture. But now we may ascertain the homological identity of these appendages, by placing these two animals in the same structural position. It will be easy to understand how, in accordance with the form and movements of the various members of the whole family, the tentacles may issue from different heights of the vertical diameter upon the sides of the body, and, according to the direction of its movements, be bent either towards the mouth or towards the anus, and thus a foundation for their correct correspondence fairly introduced. Judging from the figures of Mertens, it even appears that in the same genus this direction may be reversed; for in Beroe cucumis the tentacles are bent, and issue in the direction of the anal aperture, as is also the case in B. compressa and B. octoptera, while in B. glandiformis it is the reverse. May not this circumstance, however, coincide with some other differences in the structure of those various species referred to Beroe, and indicate the propriety of separating them generically? Judging from Pleurobrachia when contrasted with Bolina and Cydippe, we might infer that the tentacles were more and more developed in proportion as they are removed from the mouth. But Leucothea shows that oral tentacles may be as extensively developed as those which issue from the sides of the body. It is further a question, which I am not, however, prepared to answer, how far the tentacles of Beroe may be homologized with either the tentacles around the mouth, or those around the disk, of Discoid Medusæ. From their connection with the chymiferous system, I should be inclined to view the complicated branched tentacles of Beroe as corresponding to the marginal tentacles of true Discoid Medusæ, rather than as answering to the fringed lobes which surround the oral aperture in so many of the latter. The position of these tentacles with reference to the mouth bears some resemblance to what is noticed in the position of the anus in the family of Echini, where the anus may open below very near the mouth, or about the margin, or even on the upper surface of the disk, directly opposite to the mouth, without interfering with the general homology of those parts.

After this digression, if we return to a more direct consideration of the form of Bolina, we find that it differs from Pleurobrachia in the extraordinary development of two lobes on its lower extremity (Plate VII. Fig. 1, 2, and 3), inclosing, when shut, the mouth and its appendages, and extending transversely to the antero-posterior diameter, one forwards and the other backwards, so that they contribute when expanded to increase the already prominent length of the longitudinal diameter, leaving a deep transverse fissure between them, at the bottom and centre of which the mouth is situated. The body thus shuts up by the alternate approximation and separation of two valve-like lobes, hanging downwards, placed one in advance and the other backwards, in a position precisely inverse to that of the valves of Acephala, which rest upon the sides of the body, and move laterally. In addition to these two large broad lobes, there are on each side two smaller ones, which arise from the main body at about the same height as the anterior and posterior lobes, but which are simple short, narrow auricles converging or diverging alternately, and thus shutting from the side, and above the great transverse fissure of the animal. With the power which these animals enjoy of opening widely or shutting closely their anterior and posterior lobes by contraction and dilatation, bringing them alternately close together or stretching them forwards and backwards, the general appearance of the animal is constantly so completely changing, that it requires long acquaintance with them fully to appreciate the connection of all the parts in their different attitudes, and the influence of the movements of certain parts upon the position of others, and upon their functions. The activity of the circulation through the chymiferous tubes, and the position the main branches of the central cavity assume in these different changes of the general form, are constantly modified, as are also the width of the body and the power of its contractions. But in the same proportion that the extent of the longitudinal diameter is modified by the expansion and contraction of the anterior and posterior lobes, the height of the animal, compared to its width and length, is also constantly changing. If we add to this the diversity of images which are brought before us, when we watch these animals in their various movements, from different sides, facing alternately the longer or the shorter diameter, the sides, or the upper or lower surface, I venture to say that it is impossible to make correct descriptions, and to give true representations of such animals, unless they have been watched for a long time in a living state; for it is utterly impossible to examine their forms out of the water, as all parts then collapse, fall together, break in pieces, or dissolve into a shapeless mass. And, although I acknowledge the great interest of the descriptions published by travelling naturalists, making us acquainted with the great diversity of types of these remarkable animals all over the world, satisfactory illustrations cannot be expected from any quarters save those where able observers have resided for a long time, and the accounts of the generic and specific characters of most Medusæ must be considered as provisional, so long as they are not revised under favorable circumstances.

Viewed from above, that is to say, from the anal extremity, with the lobes contracted, Bolina appears very much like Pleurobrachia, assuming then the form of a slightly compressed sphere (Plate VII. Fig. 5); and were it not for the opposite direction of the circumscribed area, which runs in the longer diameter, while it is transverse to it in Pleurobrachia, the identity would be almost perfect. Seen from below, however, (Plate VII. Fig. 6,) even when the lobes are contracted, the difference is already marked, owing to the circumstance, that the vertical rows of locomotive fringes do not extend uniformly from one extremity of the animal to the other, the two ambulacra of the anterior and posterior lobes being much longer than those of the sides, which terminate at about half the height of the body.

Viewed in the same position with slightly opened lobes (Plate VI. Fig. 5), the difference between the longitudinal and transverse diameter is already more marked. But what is more striking, a considerable portion of the body seems, still further, more elongated than its general outline, and the four lateral lobes, or auricles, appear as appendages to the anterior and posterior lobes. In proportion, however, as the larger lobes expand, the small lateral lobes are successively more and more detached from them, and their real connection with the sides of the main body begins to be apparent, as in Fig. 7, 8, and 9. In this position the greater length of the anterior and posterior ambulacra, and the shortness of the lateral ones, are quite apparent. In proportion as the anterior and posterior lobes are more and more stretched forwards and backwards, their sides assume a more pointed form, similar to the horns of a crescent, or rather to the blade of a tomahawk, and the whole body, from its diminutive size, appears like two tomahawks in miniature placed head to head in opposite symmetrical directions, without handles, the four short lateral appendages looking like two small sticks projecting through the eye of the head for an equal length on both sides.

Seen from below, in the same development of all parts, the general outlines do not differ materially from the view just described, excepting that the mouth is in sight in the centre, extending forwards and backwards in the same plane as the circumscribed area opposite, and the ambulacra appear only indistinctly through the mass. Fig. 6 of Plate VII. represents such a view. The body, however, is sometimes stretched in the longitudinal diameter to such a degree as to give its outline an irregular, oblong-square form (Plate VI. Fig. 10).

Viewed in profile, the body presents also two very distinct aspects when seen by the broad face or by the narrow face, or when examined from its anterior and posterior or from its lateral side. Facing the anterior or posterior end, the symmetry of the figure, as in Plate VII. Fig. 4, arises from the parity and symmetry of the right and left halves of the body; the two sides of the anterior and posterior lobes being perfectly symmetrical. But here, again, the outlines may differ greatly, in consequence of the expansion or contraction of the lobes, which may hang down and look almost straight, with the main mass of the body above, or spread laterally and assume a rounded form, like a broad apron suspended from the chest with projecting auricles or appendages about its point of insertion (Plate VI. Fig. 6). In this position the anterior or posterior pairs of ambulacra are seen in their fullest development, extending from the summit along the middle of the lobe to its lower margin, tapering gradually as the lobes grow thinner.

Seen from the sides, the symmetry of the figure arises from the perfect symmetry and equality between the anterior and posterior extremity of the body, and the outlines may vary, as the two lobes are pressed nearer together or stretched apart to a greater or less extent. The modifications in this respect are almost endless, as also the manner in which the margins of the lobes fold over; for their lower margin may hang loosely down, as in Plate VII. Fig. 3, or it may bend inwards, curving itself in rounded or square outline, as in Fig. 2, reaching, also, over the sides, or stretching more flatly. In these various states of dilatation or contraction, the lobes may diverge from each other in all possible degrees; one may even overlap the other alternately, and thus reduce to the utmost the difference between the longitudinal and transverse axis, as in Fig. 1. The small lateral lobes, two in number on each side, may, in these various changes of form, assume also the most diversified positions; at times stretching straight downwards, at times arching upwards, at times hanging down, converging towards and even crossing each other; so that there is no end to the diversity of these aspects. I should say, however, that the motions of these lobes, especially those of the two large anterior and posterior lobes, are comparatively very slow and graceful; while those of the small lateral lobes are somewhat more brisk.

Seen from the sides, the pair of lateral ambulacra (Plate VII. Fig. 1 and 2) converge from the upper summit towards the base of the lateral lobes, and the anterior and posterior ambulacra of the same side appear in profile near the anterior and posterior margin, encircling in parallel curves the lateral ambulacra, but extending and gradually tapering all the way down to the lower margin of the lobes.

The whole animal progresses rather slowly, its movements being tremulous, like dancing in slow steps through the water, and now and then revolving upon itself. But we never see those quick, darting motions which characterize Pleurobrachia, nor any thing like the graceful curves of the tentacles following it like a comet's tail, for here the tentacles do not extend beyond the margin of the lobes. And the lobes themselves are an impediment to quick and graceful motion; for the anterior and posterior ones are disproportionate in size to the body. There is, however, an attitude in which the movements of this animal are exceedingly graceful. It is when the lateral lobes are fully expanded, and even recurved forwards and backwards, and so elongated as to appear like two flower-petals spreading in an opposite direction, and curving outwards. In this development the animal generally reverses its position, the mouth being turned upwards, and the lateral lobes also curved outwards, presenting their vibrating fringes in the utmost degree of activity, the whole animal resembling an open white flower, with two large and four small petals revolving slowly upon its peduncle, or changing its place in various directions. Fig. I. of Plate VIII. represents a specimen in such an attitude.

The ambulacra are so closely connected with the appearance of the whole animal and its movements, that we had better consider these first. As in all Beroid Medusæ, they constitute vertical rows of movable fringes, identical in structure in every respect, as far as it has been traced, with those of Pleurobrachia, the difference consisting mainly in their extent, the pairs which run along the anterior and posterior extremities of the body, and extend upon the two large lobes, being by far the longest, and also somewhat wider, their flapping combs tapering gradually towards the anal area, so that the ambulacra terminate in points at some distance from the central black speck. This is equally the case with the two pairs of lateral ambulacra, which, however, extend somewhat farther inwards, the tip of the eight ambulacra encircling an oblong area, the longer axis of which is in the same plane as the circumscribed anal area, which extends, however, far beyond forwards and backwards, between the rows of combs of the anterior and posterior pairs of ambulacra. Another peculiarity which distinguishes Bolina from Pleurobrachia, in the arrangement of this extremity of the body, is the circumstance that the body here is not simply rounded, but somewhat depressed along the longitudinal axis; so much so, that the two sides bulge sensibly above the level of the central speck, while the anterior and posterior extremities are on a level with it. The consequence of this form of the main gelatinous mass of the body is, that the upper extremity of the anterior and posterior ambulacra runs almost straight, while in the lateral ambulacra it is arched over the two rounded parallel ridges which inclose the circumscribed anal area. It is easily ascertained, that eight small tubes, similar to those observed in Pleurobrachia, extend beyond the upper extremity of the ambulacra towards the central black speck, or rather towards the bulb under it, and that they are the prolongation of the vertical ambulacral tubes of the chymiferous system. Below the main bulk of the body, along its sides, the ambulacra gradually taper also towards their lower extremity, and as soon as they reach the height of the dilatation of the lobes, the locomotive combs disappear, and the vascular tubes which accompany them can alone be traced farther. In the lateral ambulacra, however, these combs are reduced much sooner. The rows themselves taper also sooner, and terminate at the base of the small lateral lobes near their inner margin, for a considerable length above the lower extremity of the ambulacra of the large lobes. In the small lobes we trace, also, a narrow prolongation of the chymiferous tubes, which extend beyond the locomotive fringes. The course of these narrow tubes upon the lobes is very difficult to trace, and their connection with each other and with the central chymiferous cavity has been entirely overlooked by former observers, though there are, in the figures of Bolina elegans published by Mertens, indications that he noticed the outline of their convolutions. I shall first trace the course of these tubes upon the larger lobes. As long as the tubes follow a straight course in the prolongation of the anterior and posterior ambulacra, they remain at the surface of the gelatinous mass, covered only by the epidermis beyond the ambulacra themselves. But as soon as they diverge towards the sides, and approach the lower margin, where they bend to take again an inward course, they penetrate deeper and deeper into the substance, across the whole thickness of the lobe itself, till they reappear upon its inner surface, where they are nearest to each other, then rise, diverging again, and following almost exactly the outline of the lateral margins of the lobes, along which they ascend towards their bases, rising higher than the lower termination of the ambulacral combs, as high as the bases of the short ambulacra, then converge again, bend downwards, and in a sinuous, winding course descend again towards the lower margin of the lobe, remaining nevertheless above the first lower comb, and converging from the two sides immediately in the medial line; so that there is a direct communication between the right and left ambulacral tube of the anterior and posterior pairs, passing in their course from the margin of the outer surface to the middle of the inner surface, first descending, then rising, then descending again in undulating lines, until they meet to form a central continuous channel. Such a connection between any of the tubes on the oral side of the ambulacral tubes has not been seen in Pleurobrachia; but, as I mentioned when describing the structure of that genus, I should not be at all surprised if it should be finally found that there is such a connection around the mouth, for there are vascular tubes following the walls of the digestive cavity which reach the margin of the mouth, along the folds of which I have repeatedly thought I saw something like tubes and a current; but though I could never satisfy myself completely upon this point, and though I have always been unable to trace the ambulacral tubes in Pleurobrachia beyond the oral termination of the locomotive combs themselves, the existence of such minute tubes in the substance about the mouth of Pleurobrachia is rendered very probable, since it is seen here that extensive, and, indeed, even large vessels wind their course in the lobes, and we shall presently see that there is a further communication between those of the larger lobes and those of the smaller lobes, as well as between them and those around the mouth, in its margin and in the tentacular apparatus, so that the circulation of fluid from one summit towards the other, and the recurring movement in the opposite direction, are fairly established by a direct course of tubes in Bolina, though the movement of fluid in these tubes takes place in a backward and forward direction, which therefore does not imply the possibility of a complete want of such communication in Pleurobrachia, where the circulation would be reduced to a forward and backward movement in the main trunk of the system. The ambulacra of the sides are reduced to a simple chymiferous tube as soon as they reach the base of the lateral lobes, whence the tube continues in a very complicated course through the lobe and towards the mouth, and also towards the large lobe. First, the tube follows the inner margin of the small lobes, then turns round their obtuse points and retraces a parallel course in an oblique direction ; but the base branches in such a way as to unite simultaneously with a tube extending along the margin of the mouth, and with another extending into the large lobe, or it may rather be said, that an anastomosis is established at the base of the small lobes, on their external margin, with the chymiferous system of the large lobes, as well as with that of the margin of the mouth. Fig. 3 of Plate VII., in which the inner surface of the anterior lobe is turned outwards for the whole extent of its margin, shows this connection most distinctly. The anastomosis with the large lobe is established through a tube which arises from the lower sinuosities of the inner convolution of the long ambulacral tube. The communication with the oral tube is more direct, and may be considered as a branch from the tube of the short ambulacra ; indeed, both may be considered so, the anastomosis with the large lobe, as well as that with the mouth. But, in the first case, the communication with the tube of the long ambulacra is more indirect than it would be if it were placed in the course of its terminal sinuosities, where it forms frequent anastomoses ; while the connection with the oral system is direct, through a tube which only bends at right angles upon itself. What is the meaning of these numerous anastomoses upon the inner surface of the large lobes I cannot tell. Are they of the character of the gills of Brachiopods and Ascidians, or are they something of a nature more peculiar to these animals ? This remains to be investigated.

But so much is certain for the present, that the large lobes and the small lobes are not fully identical. The large lobes are a mass of the same gelatinous substance which constitutes the principal portion of the body ; while the small lobes seem simply membranous, and are really hollow sacs, a kind of *diverticula* arising from a folding of the surface of the body at the lower extremity of the short ambulacra. These lobes are, indeed, a mere fold, and the direct prolongation of the short ambulacra in every respect, though they seem as completely different from the ambulacra as they are from the large lobes. However, upon close investigation of their structure (Pate VIII. Fig. 8), it is found that their margin is encircled by vibrating cilia, and that the ambulacral tube follows the base of those cilia all round the margin of the lobe, until the cilia of the lobe disappear in their turn, and the tube alone is continued, branching, as mentioned above, into the large lobe, as well as towards the margin of the mouth.

Upon these considerations, we may, therefore, view the small lobes as a simple modification of the lateral ambulacra, bent inwards in proportion as the great transverse fissure which separates the two large lobes rises higher along the sides of the mouth, and thus introduces a loop in the lateral ambulacra, instead of a straight course, as on the sides; the vibratory cilia of the small lobes being modifications of the locomotive combs of the ambulacra proper, which would appear as long on this side as on the other, if they were stretched in the same manner, but which are here folded over in the shape of prominent auricles acting more directly and energetically as lateral oars.

If this view of the four small lobes is correct, we may consider the vertical branch or fork of the vascular tube below as the direct prolongation of the ambulacral tube proper, and the fork which diverges into the large lobes as the anastomotic fork, connecting the ambulacral tubes all round the body. The horizontal branches along the sides of the mouth should then be considered as the anastomotic branches between the two lateral ambulacral tubes of each side, and thus the circle would be made perfect.

There is a great interest connected with a further investigation of the vibratory cilia of the small lobes, in comparison with the locomotive combs of the ambulacra. For the former are so similar to common vibratory cilia, and the latter are so plainly a more advanced system of locomotive apparatus with a complicated structure, and both are morphologically so fully homologous, as to show that, in the series of natural developments, vibratory cilia are not absolutely a specific type of structure, but may constitute, in a gradual development, a natural link, connecting more complicated organs with the simplest fringes of structural cells. I entertain now so little doubt respecting such transitions, that I have not hesitated throughout these descriptions to consider the rows of vertical locomotive fringes as true ambulacra, though there is as great a difference between them and the ambulacra of Echinoderms, as there is between them and simple vibratory cilia. We are thus led to recognize through the whole type of Radiata a natural gradation in the structure of the organs through which currents of water are produced around the body, from the simplest combinations in Polypi to the most complicated apparatus in Echinoderms. In Polypi we have only vibratory cilia arising from structural cells over extensive surfaces of the whole body, while in Beroid Medusæ there are, in addition to such cilia, peculiar rows of fringes, which move by muscular action upon their bases, and in Echinoderms each fringe in the shape of an independent ambulacral type assumes as great a structural complication as the whole system taken together in Acalephæ. The ambulacral tubes in Echinoderms, and the aquiferous system with its vesicles in star-fishes, or the true ambulacral gills in Echini, seem to me, indeed, to bear the same relation to each other, as the fringes of the locomotive combs, with their basal muscles, in Beroid Medusæ, bear to the vertical ambulacral tubes.

If, from this review of the superficial ramifications of the chymiferous tubes, we proceed to an investigation of their connection with the interior stems and the central cavity of the whole system, we find a very close resemblance in their arrangement to what has already been noticed in the genus Pleurobrachia ; the chief difference between the two genera consisting in their peculiar termination and connections in the peripheric lobes. The centre of the chymiferous system constitutes in Bolina (Plate VIII. Fig. 2 and 9), as well as in Pleurobrachia, a vertical hollow axis, extending from the centre of the anal area down to the sides of the digestive cavity, being, however, not so spacious as in Pleurobrachia, while the digestive cavity itself is larger, extending nearer the central black speck, so that the funnel which branches towards the circumscribed area below the tubercle of the black speck is shorter, the main cavity from which the main trunk to the ambulacra arises being much narrower, and the tubes extending towards the margin of the mouth, along the lateral walls of the digestive cavity, being in the same proportion longer. But the general arrangement is identical. The differences exist only in the proportional development of the different parts of the whole system, as also in the curve of the ambulacral branches, which are more strongly bent upwards, instead of stretching horizontally across the gelatinous mass. Owing to the lesser development of the central cavity of this system, and the difficulty of preserving alive these animals after injecting colored liquid into the chymiferous sac, I have not succeeded in discovering a regular contraction between the right and left sides of the system. It may be, also, that the transverse diameter, being so much shorter in this genus than in Pleurobrachia, and the means of establishing a retrograde current from the periphery much more extensive, the circulation takes place through alternate dilatations and contractions of the whole body, causing an injection of the fluid in all directions, rather than by an alternate passage from one side into another ; and for various reasons of analogy I incline rather to this view. In the Discoid Medusæ, we have an absolutely radiating circulation, and a movement simply to and fro from the centre to the periphery, and back throughout the whole system. In Pleurobrachia there is an alternation between right and left, with a prominent circulation to and fro. In Bolina, there is also a bilateral symmetry, but the radiating circulation seems to be recurring in itself through a complete circle, which arrangement would already approximate the Beroid Medusæ of the genus Bolina to the type of Echinoderms, though in a lower condition of the circulating system.

Whatever may be the value of these suggestions, so much is plain, — that the digestive cavity constitutes a capacious sac with a longitudinal mouth, the fissure of which opens in the same plane with the anal area, precisely as in Pleurobrachia, in a gelatinous, oblong disk, extending with its longer diameter flat between the anterior and posterior lobes (Plate VIII. Fig. 6). This disk is entirely surrounded by the large lobes when they are shut, but it forms the lower outline of the body when the lobes are entirely open and fully spread. In this attitude the mouth is shut, but the lobes are wide open, to inclose any food that may come within reach; and whilst dropping fragments of oysters upon them, as they are generally turned mouth upwards, in this extreme state of dilatation, I have sometimes seen the lobes close upon such morsels to secure them, and afterwards the mouth expand and open within to swallow the food, the tentacles being alternately drawn out and retracted.

The visible outline of the digestive cavity changes most remarkably in these various operations. When the mouth is shut, and the digestive cavity is empty, the digestive sac is completely flattened and compressed in the direction of the longer diameter, rising like a tapering funnel towards the central chymiferous cavity above; that is to say, the fold of the digestive sac which is stretched between the antero-posterior angle of the mouth converges towards the upper extremity of the body, and the flattened walls are pressed upon each other. In this position, the vertical chymiferous tube runs downwards, and along the middle of the outer surface of the digestive cavity, and reaches, near the lateral margin of the mouth, the sac of the tentacles. But after food has been swallowed, and the mouth is contracted into a more sphincter-like shape, and the digestive cavity so much narrowed above its external fissure, that the cavity of the digestive sac appears like a loose bag widest about half its height, with prominent angles in advance and backwards, swollen also laterally, but tapering above and below. In such a state the vertical chymiferous tubes of the sides have a more curved and even sinuous course, in accordance with the position of the morsels of food within, and the upper end of the digestive sac opens freely into the central chymiferous cavity.

I have seen distinct indications of fibres in the walls of this sac. There are also marked vertical folds along its upper end, of a brownish color, darker than the transparent walls of the other parts of the sac. But I have failed to see distinctly the vibratory cilia of the upper opening, though there is a constant movement of the minute particles of digested food about the aperture of the digestive cavity leading into the chymiferous cavity.

As mentioned above, this central chymiferous cavity is not only shorter, but also narrower, in the genus Bolina than in Pleurobrachia, though the fibrous structure of its wall is much more distinct. It has also a somewhat different form, though the same disposition, its sides bulging simply outwards, instead of forming two distinct trunks for the branches to the ambulacral tubes, as in Pleurobrachia; so that the four main branches arise in pairs almost directly from the main cavity, the tubes of one side, however, at greater distances from each other than the two corresponding anterior, or the two corresponding posterior ones, owing, no doubt, to the lateral compression of the body. And from the wider space between the two main branches of one side arise again the vertical tubes, which descend along the digestive cavity, towards the base of the tentacles.

Again, the four main branches of ambulacral tubes, instead of stretching horizontally towards the ambulacra, are bent upwards, and then divide each into two branches, to provide the eight ambulacra with as many vertical ambulacral tubes. The consequence of this arrangement is, that the impulse of the liquid pressed into the ambulacral tubes is chiefly in one direction, the branches from the main cavity meeting the ambulacra near their upper termination, and not at about half their height, as in Pleurobrachia. So that the chief current, and, I may say, almost the only constant current, is downwards along the sides, following the ambulacra, and all the sinuosities of their tubes in their lower course through the great lobes, as well as through the lateral auricles; and a comparatively very small portion of fluid flows towards the upper centre, through the very thin tubes extending from the upper summit of the ambulacra towards the anal area. The main antagonism between the currents, therefore, is between the upper and lower extremities of the body, and by no means between the right and left side, and *vice versâ*. Whether, however, the retrograde movement takes place upwards, through the same tubes in which it has moved downwards, or whether the winding course of the narrow tubes in the lobes constitutes a kind of capillary system, through which the liquid passes from one side of the ambulacral tubes into the other, I am unable to decide. But I cannot help thinking that this long winding course of the ambulacral tubes, upon the inner surface of the large lobes, and along the margins of the auricles and mouth, contributes to a more extensive aeration of the chyme in circulation than the straighter course in the wider vessels of the whole system in Pleurobrachia. But perhaps the more active alternate contractions in Pleurobrachia compensate by their quicker movements for the deficient ramification of the tubes themselves, which is so extensive in Bolina.

Of the narrow tubes about the anal area, I shall have to speak again presently. I shall only add here, that the vertical tubes upon the sides of the digestive cavity enlarge near the middle of the lateral margins of the mouth into a small, bulb-like dilatation, from which a bunch of tentacles may be issued or retracted. But this bulb is by no means so complicated as the tentacular sac of Pleurobrachia. There is no flat disk with elastic springs, but simply two narrow tubes arising from the main cavity, a little outside of the tubes of the digestive cavity, and following its course to the tentacular bulb. As, on account of the lateral pressure, the tubes of the digestive cavity and those of the tentacular bulb are brought into close contact, they appear at first sight to constitute a single cord on each side; but in reality that cord consists of three tubes running in the same direction, which, being close together, are very easily mistaken one for the other, and whose natural connections are still more difficult to ascertain, as the bulb of the tentacle exactly covers the termination of the tube, resting immediately upon the digestive cavity and extending to the margin of the mouth. But whenever, by an oblique movement of the margin of the mouth, or by the dilatation of the tube, one way or the other, out of the vertical direction, the superposition of the bulb of the stomachal tube is disturbed, it must be seen how the tube of the digestive cavity divides into two horizontal branches, extending in opposite directions along the lateral margin of the mouth forwards and backwards, at right angles with the tube from which they arise, so that a direct communication is here established between the peripheric course of the ambulacral tubes and the main central cavity, a communication which very likely gives passage to the recurrent fluid, which does not return through the same tubes in its course. As for the two small tubes which unite in the bulb of the tentacles, they arise from the same lateral bulging of the same cavity from which the lateral tube of the stomach originates, but they arise more vertically.

The greater simplicity of the tentacular bulb has reference, no doubt, to the shortness of the tentacles, and to the circumstance that they are not protruded to any length beyond the margin of the mouth, but simply extend in a winding course forwards and backwards along that margin, forming, when contracted, a compact bunch, and appearing, when expanded, like a disorderly brush of irregular curled threads tied together on one side.

The best position in which to study the ramifications of the tubes on the side of the digestive cavity along the outer margin of the mouth, and the position of the tentacular bulb still farther outward, is when the animal is turned mouth upwards, with its large lobes fully expanded, when the mouth appears like a narrow rim in the centre of the prominent gelatinous mass between the large lobes which constitute a sort of compressed isthmus between the antero-posterior extremity of the body, along the margin of which the horizontal tubes from the stomachal tube are seen to extend as far as the right margin of the lateral auricles, without entering into direct communication with the tubes of the tentacular bulb. See Plate VIII. Fig. 6.

The walls of the central chymiferous cavity, and the main trunks which arise from it, are distinctly fibrous, and may easily be seen to shorten or elongate, and enlarge or contract their cavity.

The funnel enlarges above into two distinct branches, forming two bulbs, as in Pleurobrachia, with oblique openings forwards and backwards, on the sides of the circumscribed area, and with the black speck in the centre. This black speck has also a distinct ring, and it has seemed to me almost evident tha this ring extends, in the form of narrow tubes, along the margin of the circumscribed area, and also that the eight narrow tubes converging from the summit of the ambulacral combs empty into this ring; and as the ring itself is a fold from the prolongation of the funnel into the cavity extending forwards and backwards under the circumscribed area, it would follow that these eight tubes communicate here with the central chymiferous cavity, as they communicate from below through the tube around the mouth, an arrangement which would complete the circulation, the main movement of which would seem to follow the ambulacra downwards, with a small eddy upwards towards the eye-speck, and with a main recurrent stream along the digestive cavity. I should add, that the relative position of the eight narrow tubes from the ambulacra, where converging towards the anal area, differs considerably between the different pairs, the two anterior and the two posterior ones being very near together, almost in the longitudinal axis; and the two tubes of the two lateral pairs being, on the contrary, as far apart from each other as they are from the anterior pairs. So that there seems to be only six tubes meeting the central funnel, when in reality the anterior and posterior are each double.

I have not succeeded in making out a distinct nervous system connected in any way with the central tubercle, though numerous fibres diverging in all directions may be seen in connection with the upper part of the funnel. But it has always seemed to me that they are rather muscular fibres than nervous threads, for they change their length, and are by no means so symmetrically arranged as might be expected in a nervous system in these animals, when we know its disposition in other types of the class. This region, however, and the periphery of the mouth, are the places to look for it. But notwithstanding all efforts, I confess I have failed in the search.

With regard to Pleurobrachia, I have already expressed my opinion respecting the organic nature of the central black speck, which presents precisely the same appearance in Bolina, and the same general relations with the surrounding parts right and left, forwards and backwards, and below. The bulb below seems to me really to be simply a central projection of the chymiferous cavity, the ring around it something like the ring of Sarsia around its central tubercle, and the eight narrow tubes diverging from the summit homologous to the four vertical tubes of the Naked-eyed Medusæ, the whole differing only by the presence of apertures through which the refuse matters are discharged from the chymiferous cavity.

The extraordinary transparency of the gelatinous mass, and the impossibility of preserving the animal after death in a contracted state, forbid the prospect of ever knowing fully the arrangement of the contractile fibres throughout the body. The general arrangement is very probably the same as in Pleurobrachia; for in some dying specimens, I have seen, at some distance from the central black speck, eight points between the ambulacra, alternating with them, arranged, as in Pleurobrachia, in the form of an oval, which indicate probably the presence of as many vertical bundles of fibres running from the upper summit downwards, and regulating the movements of the lobes jointly with circular fibres, which are more easily detected, and occur in great numbers grouped together in bunches along the sides of the vertical rows of locomotive fringes in the space intervening between their combs, and extending brush-like horizontally into the substance, though diverging in each bundle. These fibres seem more powerful, and, at all events, far more distinct, than the vertical muscles, which I have never been able to trace in continuous rows. Some means might perhaps be found to preserve their bodies in such a way as to bring out the muscular fibres. It would, indeed, be very interesting to study their arrangement, especially with reference to the motions of the large lobes.

Though I have watched specimens of this species at short intervals through six successive months, from December to June, I have never succeeded in discovering the sexual system, not even in the most rudimentary state. Should it, however, be found to follow in its development the course of the ambulacral tubes, as reported by Wild, this fact would go far to show the homology, to which I have above alluded, between the ambulacral tubes of Beroid Medusæ, and the vertical chymiferous tubes of Naked-eyed Medusæ. The circumstance of my failing to trace the reproductive system after so long a search, may show how great difficulty these investigations are attended with, and how much remains to be done before the whole history of these animals is satisfactorily made out.

Of their embryonic development nothing at all is known; but from the character of the black specks, I would repeat what I have said of Pleurobrachia, that I suppose them to be developed from Hydroid Polypi.

I have observed a third Beroid Medusa on the shores of Massachusetts, in Edgartown harbour and at Nahant, belonging to the genus Idya, but it was under such circumstances that I could neither examine it carefully, nor have drawings of it made to my satisfaction. I may say, however, that this species, at least in the condition in which it was observed, is much smaller than any of those described before. I regret the more to have been prevented from making a minute investigation of it, as that genus is particularly remarkable for the lateral ramifications of the ambulacral tubes, and it would be very important to compare these ramifications with the radiating ramifications of the chymiferous tubes in Discoid Medusæ.

The extraordinary metamorphoses of star-fishes and Echini, which Professor Müller first observed, ought not to be neglected in the study of Beroid Medusæ; for the remarkable resemblance between the singular transparent frame which protects the growing embryo of the star-fish and the body of Beroid Medusæ cannot be overlooked by an attentive observer; and the fact, that the parts of that external frame present numeric combinations which are unusual among Echinoderms, but which correspond to those of the Beroid Medusæ, will be an inducement to institute, at some future day, a close comparison between their structure and that of the Beroids. The ciliated appendages which hang downwards in those animals resemble closely the vertical rows of locomotive fringes with their chymiferous tubes, as observed in Beroid Medusæ. And it is interesting to find hat in Echinoderms there is a metamorphosis going on in the embryo, recalling the structure of the inferior class of Acalephæ in a manner very similar to the analogy which exists between the embryos of Medusæ and Polypi. For whether we compare the Strobila in its earliest conditions, or the young buds of Hydroid Polypi when producing Medusæ, the analogy of this earliest state of development of Acalephæ with Polyps is unmistakable, and I have no doubt that the external frame of the young Asterias and Echini, which Professor Müller has so beautifully illustrated, will be found to bear the closest resemblance to the structure of Beroid Medusæ, as soon as an actual comparison can be instituted with reference to the analogy of their structure, which is far more difficult to trace from descriptions and figures, however accurate these may be; but Professor Müller's attention seems not to have been attracted by this remarkable analogy, which he might have traced so fully when studying these embryos. So much, however, may be said already, that the general arrangement of the ciliated lobes of Plutus corresponds to the ambulacral rows of Pleurobrachia and Bolina, and that the tubes which accompany them compare closely with the vertical chymiferous tubes of the same Medusæ. Notwithstanding my efforts to observe the various developments of Asterias, I have, up to this time, been able to trace their growth only in the peculiar forms first described by Sars.

EXPLANATION OF THE PLATES.

The genera Pleurobrachia and Bolina, though apparently closely allied, and differing chiefly in the development of gelatinous lobes in the genus Bolina which do not exist in Pleurobrachia, present peculiarities which require the most careful comparison in order fully to understand their true relations. It has appeared to me, on that account, very desirable to mark the different parts in both with corresponding letters, in order to prepare the reader for the closest comparison, and a true estimation of their different direction in the surrounding medium. The different bearing of the separate rays, the difference in length of their longitudinal and transverse diameters, the inverse position of the mouth in their normal attitude, the apparent transposition of the tentacles, which seem turned towards the circumscribed area in Pleurobrachia, while in Bolina they accompany the main cavity of the edge of the mouth, are so many features in their structure which cannot be fully appreciated in their respective differences, unless the different species are placed in an identical position when compared. I have, therefore, assigned definite numbers to the different rays or rows of combs and radiating tubes, and marked them with corresponding figures, so as to enable the reader to institute the comparison, either by inverting Pleurobrachia, mouth downwards, to give it the same position as that which is normal in Bolina, or inverting Bolina, mouth upwards, in order to compare it in the same attitude as that in which we usually observe Pleurobrachia when moving. But I may repeat what has already been mentioned above, that occasionally both species may be observed in an attitude the reverse of that which they usually assume.

Before remarking upon the figures which fill the plates accompanying this paper, it will facilitate such comparisons, and the understanding of the individual figures, if I proceed first with an explanation of the letters with which the different parts are marked, which are precisely the same for all the figures in both genera.

A, B. Gelatinous lobes encircling the mouth, so large in Bolina as to form the greater bulk of the body. The two lobes, as developed in Bolina, are opposed to each other in the axis of the plane of the circumscribed area and of the mouth, so that they open and shut against the extremities of the longitudinal fissure of the mouth.

a. The mouth. It assumes the most diversified outlines when shut or expanded in various ways.

b. The narrow tube of the anterior part of the alimentary cavity, being a sort of gizzard or special division of the alimentary canal corresponding to the anterior portion of its tract in other animals.

c. The lower division of the alimentary cavity, performing simultaneously the functions of a stomach and those of a colon; for upon its walls we observe brown hepatic cells, but at the same time there is at its bottom an opening, through which the substances which have been digested are emptied into the main cavity of the body, *d*. This whole digestive cavity hangs free in the main cavity, and is truly the analogue of the alimentary sac of Polypi, as observed in Actinia, and may also fairly be compared with the alimentary cavity of Echinoderms, especially with that of star-fishes; though here the sac may be closed, as it never is in our jelly-fishes, or may empty outside of the animal, while in our Medusæ it empties into the main cavity.

d. The main cavity of the body, in which the products of digestion are circulated, mingled with water. This cavity corresponds truly to the main cavity of Polypi, with this difference, that in Polypi there are only partitions dividing it off around the periphery, while in Medusæ the gelatinous mass of which the body consists fills, to a great extent, the inner space of the animal, and leaves only tubes for the peripheric circulation of the fluid contained in it. There is one vertical prolongation, *f*, of this main cavity, extending in the direction of the circumscribed area, and which branches into two forks, f', f'', at its termination. The other tubes arising from it are the two main chymiferous horizontal tubes, *e*, *e*, with their branches, *q*, *q*, and their eight terminal forks, *i*, *i*, which open into the vertical tubes, *v*, *v*. The tubes *r*, *r*, which follow the walls of the digestive cavity, arise also from it near the main horizontal trunks, and from these latter arise the tubes of the tentacular apparatus, *a*, *a*.

e, *e*. The main horizontal trunks of the chymiferous tube, from which arise the eight radiating branches.

f. The vertical, funnel-like prolongation of the main cavity of the body.

f', f''. The two forks of that funnel. It should be remarked that the direction of that fork is in the plane of the longest diameter of the circumscribed area, which is also the direction of the longitudinal diameter of the mouth.

g. The roots of the tentacle.

h, h^1, h^2. h designates the whole tentacular apparatus, with all its complicated parts, h^1 being the tentacular apparatus of one side, and h^2 the tentacular apparatus of the opposite side. And these numbers are appropriated to the same apparatus in every figure, whatever may be the position in which the animal is observed. It will be noticed that these tentacles are placed at right angles with the plane of the mouth and the circumscribed area.

i. The eight horizontal tubes of the chymiferous apparatus which reach the vertical tubes, following the vertical combs. In all the figures the horizontal tubes are numbered in the same way, beginning with No 1 and ending with No. 8. Number 1 is assigned to that tube which extends to the vertical comb in sight on the left hand when the mouth is turned upwards and the tentacular apparatus appears symmetrically on the right and on the left; so that i^1, i^2, i^3, i^4 are the four horizontal tubes of one half of the body, and i^5, i^6, i^7, i^8 are the four horizontal tubes of the opposite half. And if the view I have taken of the diameters of these animals is correct, that the longitudinal diameter of the mouth divides the body into symmetrical halves, one right and the other left, the tubes i^1 to i^4 are the tubes of the anterior half of the body, and the tubes i^5 to i^8 are the tubes of the posterior half, and the tubes i^2, i^1, i^8, i^7 are the tubes of the left side, and the tubes i^3 to i^6 are those of the right side, or *vice versâ*, as we can only establish these general relations between the different diameters without determining strictly which is the anterior and which is the posterior edge of the mouth. It is probable, however, that no distinction is intended in the structure of these animals, as they are capable of assuming inverse positions, mouth upwards and mouth downwards, in which case the edges of the mouth appear in an inverse position.

j indicates the cavity in which the tentacular apparatus is suspended, and to the inner wall of which it is attached. This cavity opens in j', and through this opening the tentacle may be extended; but it is also capable of such contraction as to be entirely withdrawn within the cavity *j*.

j'. Opening of the tentacular cavity, through which the tentacle is protruded.

k. The main stem of the tentacle from which the fringes arise.

k'. Fringes of the tentacles which arise uniformly upon the same side, the outside of the tentacle, so that they are stretched in opposite directions from the two sides. But this direction is constantly modified in the various attitudes and the various degrees of elongation of the tentacles, as these are capable of being twisted upon themselves; so that the fringes may appear as forming a spiral upon the main stems, or may be stretched in all possible directions, in their more or less extensive elongations. However, at the base they arise strictly in opposite directions.

l, *l*. The vertical combs of locomotive fringes, of which there are eight of uniform length in Pleurobrachia, but four longer and four shorter ones in Bolina. These vertical combs are numbered in the same manner as the horizontal tubes which open into the vertical tubes accompanying the combs, and these numbers correspond in the different figures, in the same manner as in the tubes; l^1 to l^4 being the combs of one extremity, and l^5 to l^8 those of the other extremity, and l^2, l^1, l^8, l^7 being the combs of one side, and l^3 to l^6 the combs of the other side. Upon close examination, it will be found that the short combs in Bolina correspond to l^1 and l^8 of one side, and to l^4 and l^5 of the opposite side, of Pleurobrachia; that is to say, the short combs on the right and on the left side of Bolina embrace respectively the tentacular apparatus of the right and of the left side.

m represents the muscular apparatus surrounding the mouth; *m* indicating the radiating fibres through the agency of which the mouth is opened, and m' the circular fibres which shut it.

n represents the main vertical muscular bundles, alternating with the vertical rows of combs. Towards the circumscribed area, these rows assume a more pennate arrangement, which is designated by the letter *t*. Other fibres also diverge around the opening of the cavity containing the tentacular apparatus, and form a sort of constrictor, *p*.

o. Pennate bundles of muscular fibres attached to the sides of the vertical rows of combs and penetrating more or less into the substance of the gelatinous mass.

p. Horizontal bundles of muscles extending between the vertical rows of combs and the main muscular bundles.

p'. Diverging fibres of the main muscular vertical bundles, forming a kind of sphincter around the tube leading into the cavity of the tentacular apparatus.

q. The main trunk from which the eight radiating chymiferous tubes arise. It should be noticed that these tubes are not strictly in the same horizontal plane, since their respective position varies more or less in the different contractions of the body, and those on one side are successively higher than those of the opposite side in the alternate contractions of the opposite halves of the body, which regulate the general circulation of the nutritive fluid.

r. The chymiferous tubes following the digestive cavity. They arise from the main horizontal tube, and extend to the margin of the mouth, following the middle of the flat surface of the digestive cavity.

s. Eight narrow tubular prolongations of the vertical chymiferous tubes, which taper at the summit of the vertical rows of locomotive combs, and extend towards the centre of the circumscribed area, where they empty into the vertical funnel of the main chymiferous cavity.

t. Prolongation of the main vertical bundles of muscular fibres towards the circumscribed area, which follow the course of the narrow prolongation of the vertical chymiferous tubes, diverging like pennate muscles.

u. Combs of locomotive fringes.

v. Vertical chymiferous tubes, which accompany on the inner surface the rows of locomotive combs.

v'. Areolar space upon the inner surface of the vertical chymiferous tubes, from which the eggs are probably developed.

w. Base of attachment of the locomotive combs, from which the isolated fringes arise, and to which the muscular fibres moving these fringes are attached.

x. Ganglion, probably of a nervous character.

y. Ganglion-like bodies, arising probably from the accumulation of granules in the contracted state of the vertical chymiferous tubes when the circluation has ceased.

z. Free granules moving in the vertical chymiferous tubes.

a. Chymiferous tubes of the tentacular apparatus.

a'. The opening through which the vertical chymiferous tubes of the tentacle open into the main horizontal chymiferous tubes between their main forks.

β. Swollen margin of the elongated disk from which the tentacles arise.

γ. Medial keel arising from the summit of the elongated disk of the tentacle, and extending to the base of the tentacle itself.

δ. Eye-speck in the centre of the circumscribed area.

ϵ. Circumscribed area.

ϵ'. Raised line following the inner outline of the circumscribed area, probably the analogue of that row of fringes so conspicuous within the circumscribed area in some other genera of Beroid Medusæ, and particularly distinct in the genus Idya.

ϵ''. Another line parallel to the former, and within it, the special nature of which I have failed to ascertain.

ζ. The openings of the two bulbs of the vertical funnel through which the fecal matters are occasionally discharged.

η. Revolving bulb of fecal matter.

θ. The tubercle upon which the eye-speck, δ, rests.

ι, κ. Concentric swellings connected with the ganglion of the eye-speck, stretching in the direction of the longitudinal diameter of the circumscribed area.

λ. Four ganglionic swellings within the inner of the swollen margins near the ganglion of the eye-speck, the nature of which I have also failed to determine.

μ. Longitudinal muscular fibres of the main thread of the tentacle.

ν. Longitudinal fibres of the fringes arising from the sides of the tentacle extending across the main thread, where they appear as transverse fibres.

ξ. Coating of heterogeneous cells all round the main thread and its lateral fringes. The larger ovate cells are lasso-cells.

π. Prolongation of the vertical chymiferous tubes extending from the oral extremity of the short rows of locomotive combs to the auricles, and following the inner margin of the latter.

π'. The returning tube following the outer margin of the auricles, and anastomosing with tubes from the inner surface of the large lobes, ϕ, and also with tubes, v, arising from the margin of the mouth.

ρ. Prolongation of the vertical chymiferous tubes, extending from the anal extremity of the long vertical rows of locomotive combs upon the outer surface of the large lobes.

ρ'. The same tubes turning upwards and inwards.

σ. The prolongation of the same tubes upon the inner surface of the large lobe, winding again in an opposite direction, and forming several sigmoid curves.

τ. The extremity of the same tubes extending again downwards parallel with the corresponding tube of the opposite side, both meeting upon the median line in τ'. From these tubes arises a network of tubes, forming more or less rectangular meshes, — perhaps a sort of gill, ω, from which arises a recurrent tube, ϕ.

v. Tubes arising along the margin of the mouth from the vertical chymiferous tubes, r, which accompany the main digestive cavity.

ϕ. Recurrent tube arising from the margin of the internal network of vessels which spreads over the inner surface of the large lobes. This tube, following a course parallel to the edge of the large lobes, anastomoses near the base of the auricles with the recurrent chymiferous tubes, π, of the auricles, and the tubes, v, from the margin of the mouth.

χ. Auricles, four in number, corresponding to the short vertical rows of locomotive fringes, and therefore analogous to the vertical rows l^1, l^8, l^4, l^5. In accordance with this correspondence, the auricles are respectively marked $\chi^1, \chi^8, \chi^4, \chi^5$.

ψ. Vibratile ciliæ along the auricles.

ω. Vascular network upon the inner surface of the large lobes.

Plate I. — Various Attitudes of Pleurobrachia.

Fig. 1. A specimen in a state of rest, the tentacles hanging loosely downwards partly expanded, partly contracted into irregular tubercles; the fringes not expanded. The position of the specimen is such as to correspond to Fig. 3 of Plate II.

Fig. 2. A specimen with the body in nearly the same position, but bending obliquely forwards, the tentacles fully out, the fringes also expanded, except those near the base of one of the tentacles, which are partly contracted.

Fig. 3. A view similar to that of Fig. 1; the body, however, slightly turned upon the corresponding vertical axis, so that the three posterior vertical rows of locomotive fringes, which are not observable in Fig. 1, appear through the transparent gelatinous mass.

Fig. 4. Another view, in which the body has the position of Fig. 1 in Plate II.; one of the tentacles is contracted, the other fully expanded.

Fig. 5. View from the oral side of the body, corresponding to Fig. 5 of Plate II. The tentacles fully expanded.

Fig. 6. A view similar to that of Fig. 1; the body, however, very much elongated, moving forwards, the tentacles fully expanded.

Fig. 7. A view of the animal with the body also elongated, moving horizontally, the profile corresponding to that of Fig. 4; the tentacles stretching at right angles; one with all the fringes out, bending upon itself, while the other is partly contracted, with only a few of the fringes expanded.

Fig. 8. A specimen with the body horizontal, the tentacles considerably expanded. This figure corresponds to Fig. 7, where the elongation of the body has ceased.

Fig. 9. A view of the animal nearly in the same attitude as in Fig. 1, but slightly turned more upon its vertical axis. The tentacles slightly expanded; the fringes drawn in, the extremity of one of the tentacles coiled upon itself.

Fig. 10. A view from the side opposite to the mouth; the circumscribed area in the centre, but somewhat bent upwards, in order to show the branches of all the horizontal chymiferous tubes. The tentacles are in the utmost state of elongation.

Fig. 11. An oblique view, partly profile, partly from the side of the mouth. The parts in sight correspond to Fig. 2, only in an inverse position; the tentacles moderately expanded.

Fig. 12. A specimen moving downwards. The organs in sight correspond to Fig. 3, but in an inverse position; the tentacles slightly expanded, one of them coiled upon itself for some length, with a few fringes expanded.

Plate II.

Fig. 1. *Pleurobrachia rhododactyla* in a vertical position, the main cavity and the digestive cavity in sight from its narrow surface, and the tentacular apparatus right and left. Fig. 5 gives a view, from the side of the mouth, of all parts in the same respective position; and Fig. 4, another view from the opposite side, where the circumscribed area is seen in the centre.

Fig. 2 represents the same in profile, but in a position at right angles with that of Fig. 1, so that the main cavity of the body is seen from its broad surface, and one of the two tentacular apparatus in the centre of the figure. To bring Fig. 4 and 5 to agree in position with Fig. 2, they should be moved 90° upon their axes.

Fig. 3 gives another profile view intermediate between that of Fig. 1 and that of Fig. 2; so that the two tentacular apparatus are in sight, but in an oblique position forwards and backwards, and not right and left, as in Fig. 1, or in the centre, as in Fig. 2.

Fig. 4, 5. To bring Fig. 4 and 5 into the same position, they should be turned 45° upon their axes.

Fig. 6. A part of one of the vertical rows of locomotive combs, behind which is seen the vertical chymiferous tube, into which opens one of the horizontal radiating tubes.

Fig. 7. A portion of one of the vertical chymiferous tubes, the fringes of the locomotive combs being removed to show the bases of the latter, and the ganglia behind them.

Fig. 8 represents half the width of a vertical chymiferous tube, with muscular fibres behind it, and the granules circulating in its cavity.

Fig. 9 represents a portion of a vertical chymiferous tube similar to that of Fig. 7; but the tube is more contracted, and its walls so folded longitudinally as to present distinctly several parallel waving lines, which have no existence in reality when the tubes are fully expanded, but appear only when the tubes are separated from the body, and empty. The same lines appear also in Fig. 7.

Fig. 10. The mouth widely open, with the muscles which open and shut it around.

Fig. 11. The mouth when fully shut.

Plate III.

Various figures to show the course of the chymiferous tubes, the relations between the alimentary cavity and the main cavity of the body, and the connection of the tentacular apparatus with the chymiferous tubes. To render the figures more distinct, the fringes of the vertical rows of the locomotive combs have been omitted. The chymiferous tubes and the main cavity of the body are shaded. In Fig. 6 and 7, however, the shaded parts represent the digestive cavity.

Fig. 1. Corresponding in position to Fig. 2 of Plate II., and showing the connection of the four vertical chymiferous tubes of one side with the main horizontal chymiferous tube, the vertical funnel, the tentacular apparatus, and the vertical chymiferous digestive cavity.

Fig. 2. Corresponding in position to Fig. 1 of Plate II., and therefore placed in a position at right angles with that of Fig. 1, to show the relations of the chymiferous tubes and the main cavity in that position.

Fig. 3. The same parts seen from the side of the circumscribed area.

Fig. 4. The same parts seen from the side of the mouth.

Fig. 5. The tentacular apparatus in its cavity, to show the origin of the tentacle and the connection of the vertical chymiferous tubes of the tentacle with the main horizontal tube, and its branching forks.

Fig. 6. The digestive cavity entirely empty, and flattened in the position of Fig. 2.

Fig. 7. The same cavity, more expanded. In *c*, the brown cells at the lower extremity of the cavity give its surface a peculiar appearance.

Fig. 8. The vertical chymiferous tubes of the tentacular apparatus, in their connection with the main cavity, the horizontal tubes, and the funnel, are represented in an ideal outline, without any part of the tentacles themselves.

Fig. 9. One bulb of the vertical funnel seen from its narrow side, to show a ball of fecal matter accumulating near the opening of that cavity.

Plate IV.

This plate represents the general appearance of the body of Pleurobrachia enlarged and in various attitudes, and gives also several longitudinal and transverse sections of the body, to bring out more fully the relations between the different parts.

Fig. 1 represents the animal in the same position as Fig. 3 of Plate II.

Fig. 2 shows the animal in the same position as Fig. 1 of Plate II.

Fig. 3 represents it in the same position as Fig. 5 of Plate II.

Fig. 4 represents it in the same position as Fig. 4 of Plate II.

Fig. 5 represents it in the same position as Fig. 2 of Plate II.

Fig. 6 and 7. These transverse sections correspond to the line A B of Fig. 2, which letters (in this figure) have no reference to the lobes of Bolina and the swellings around the mouth of Pleurobrachia, marked also A and B.

Fig. 8 represents a vertical section in the position of Fig. 2.

In all these figures the cavities shaded with black lines are the chymiferous cavities and chymiferous tubes. The main stems are cross-barred wherever they are cut, in the section, and the openings of the chymiferous tubes are also cross-barred. The cavity of the tentacular apparatus is marked in addition by lines of dots. On contrasting Fig. 6 with Fig. 7, it will be perceived that Fig. 6 corresponds to a section across Fig. 2 at A, passing through the upper part of the tentacular apparatus; so that the tentacular cavity forms a crescent-shaped opening around the tentacular apparatus. The lower part of the cavity is marked by dotted lines, as are also the horizontal radiating tubes seen below. In Fig. 7, which is a section corresponding to B of Fig. 2, the lower part of the tentacular cavity is laid open at a point where it is occupied internally only by the tentacle itself, and all the radiating tubes and the fringe of the vertical funnel are in sight. In Fig. 8, the digestive cavity and the main cavity of the body, and the whole tentacular apparatus, are laid open by a vertical section, and the position which the tentacular apparatus holds within its cavity is fully displayed.

Plate V.

This plate represents various structural details of Pleurobrachia more highly enlarged.

Fig. 1. Part of a tentacle contracted, and the fringes arising from one side. The two fringes on the opposite side are simply displaced by pressure.

Fig. 2 represents the structure of the tissue under the vertical chymiferous tubes, where it consists of large, irregular cells, probably an ovary.

Fig. 3, 4, 5, 6 represent the mouth in various degrees of dilatation, assuming different forms, sometimes quite irregular, as in Fig. 3 and 4; sometimes elongated, as in Fig. 5; sometimes funnel-shaped, as in Fig. 6.

Fig. 7. The mouth in this figure is entirely shut, assuming a longitudinal form, which, in its direction, corresponds to the direction of the circumscribed area.

Fig. 8 represents a small portion of a tentacle greatly enlarged, to show the structure of the main stem and that of the fringes.

Fig. 9 represents the circumscribed area, the bulb of the eye-speck, and the two bulb-like dilatations of the vertical funnel.

Fig. 10 represents the bulb of the eye-speck, and the surrounding parts still more enlarged.

Plate VI.

Various attitudes of *Bolina alata* of the natural size.

Fig. 1 shows the animal as seen in profile. The two lobes, which are entirely shut, appear on the right and left.

Fig. 2 gives a view from above, with the same position of the parts, the lobes, however, projecting a little more, and the auricles crossing each other.

Fig. 3. A view of the same from below, corresponding, in the arrangement of these parts, to Fig. 2.

Fig. 4. A profile view of the animal in the same attitude as in Fig. 1, but with the lobes opening.

Fig. 5. A view from above, in the same position as that shown in Fig. 2, but with the lobes expanding in the direction of the auricles, so that the longitudinal diameter is less when compared to that in Fig. 2.

Fig. 6. A profile view in a position at right angles with that of Fig. 1 and 4; so that one of the lobes is in sight, with its broad outer surface, and the four auricles appear as projections in two pairs on the right and left.

Fig. 7. A view from above, in the position of Fig. 2 and 5; but the lobes are expanded, and the auricles are stretching in parallel directions.

Fig. 8 represents the same as seen from below, also in the same position as that shown in Fig. 3, but with the lobes open; so that the mouth is entirely uncovered.

Fig. 9 gives a view of a specimen in the same position as that shown in Fig. 7, the lobes, however, still more elongated; so that the longitudinal diameter of the animal exceeds by far the transverse diameter.

Fig. 10 represents the same from below.

On comparing all the figures in this plate, we have Fig. 1 and 4 in the same attitudes, differing only in the degree of expansion of the lobes. We have Fig. 2, 5, 7, and 9, views from above, differing, also, chiefly in the degree of expansion of the lobes. Fig. 3, 8, and 10 are views from below, facing the mouth, differing also in the degree of expansion of the lobes. While Fig. 6 represents a profile view, in a direction at right angles with that shown in Fig. 1 and 4.

Plate VII.

Enlarged figures of *Bolina alata*, in various attitudes.

Fig. 1. Corresponding to Fig. 1 of Plate VI.

Fig. 2. Corresponding to Fig. 4 of Plate VI.

Fig. 3. In the same attitude, the lobes still more expanded, and turned inside out.

Fig. 4. Corresponding to Fig 6 of Plate VI.

Fig. 5. A view from below, corresponding to Fig. 3 of Plate VI., the lobes, however, being farther open, so as to entirely uncover the mouth.

Fig. 6. Corresponding to Fig. 2 of Plate VI.

Fig. 7 gives an enlarged view of the horizontal chymiferous tubes, and their connection with the vertical funnel below the circumscribed area and the bulb of the eye-speck.

Plate VIII.

Fig. 1. A profile view of *Bolina alata*, in the same position as that given in Fig. 3 of Plate VII., but more elongated, and turned mouth upwards.

Fig. 2. A view of the main chymiferous cavity, to show its connection with the radiating tubes, the vertical funnel, and the tentacular apparatus.

Fig. 3. A highly magnified view of the vertical funnel and the bulb of the eye-speck, with the base of the radiating tubes.

Fig. 4. The base of the tentacular apparatus in its connection with the walls of the mouth; seen in profile.

Fig. 5. A similar view, the specimen, however, placed obliquely, to show the two parallel edges of the mouth.

Fig. 6. A view of the mouth from below, with the chymiferous tubes following its edge between the fissure of the mouth and the tentacular apparatus, and anastomosing with the chymiferous tube of the auricle.

Fig. 7. An enlarged view from above, corresponding to Fig. 7 of Plate VI.

Fig. 8. The auricles greatly enlarged, to show the prolongation of the chymiferous tubes, which wind their course along through the margin of the auricles, to form an anastomosis with the chymiferous tubes from the large lobe, and from the mouth.

Fig. 9. A general view of the main stems of all the chymiferous tubes, seen from above, where the horizontal radiating tubes are most prominent; the tubes of the tentacular apparatus and the walls of the cavity appearing upon the sides of the bulb of the eye-speck, and the tubes which encircle the mouth being seen faintly through the substance of the body.

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James B. Francis, *Lowell.*

G.

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Benjamin A. Gould, Jr., P. D., *Cambridge.*
Asa Gray, M. D., *Prof. Nat. Hist., Harv. Univ., Cambridge.*
Francis C. Gray, LL. D., *Boston.*
Horace Gray, A. M., *Roxbury.*
Benjamin D. Greene, M. D., *Boston.*
Arnold Guyot, A. M., *Cambridge.*

H.

Nathan Hale, A. M., *Boston.*
Jonathan P. Hall, *Boston.*
Thaddeus William Harris, M. D., *Librarian of Harv. Univ., Cambridge.*
Augustus A. Hayes, M. D., *Boston.*
George Hayward, M. D., *Ex-Prof. Surg., Harv. Univ., Boston.*
James Hayward, A. M., *Reading.*
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Samuel Hoar, LL. D., *Concord.*
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Rev. Mark Hopkins, D. D. *President of Williams College, Williamstown.*
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Rev. Heman Humphrey, D. D., *Ex-President of Amherst College, Amherst.*

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Charles Jackson, Jr., A. B., *Boston.*
John B. S. Jackson, M. D., *Prof. Path. Anat., Harv. Univ., Boston.*

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Morrill Wyman, M. D., *Cambridge.*

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Sir Charles Lyell, F. R. S., *London.*
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F. J. D. Arago, *Paris.*
Elie de Beaumont, *Paris.*
Jean Baptiste Biot, *Paris.*
A. L. Cauchy, *Paris.*
Joseph Decaisne, *Paris.*
Jean Baptiste Dumas, *Paris.*
Milne Edwards, *Paris.*
Jean Baptiste Benoit Eyries, *Paris.*
Benoit Fourneyron, *Paris.*
Adrien de Jussieu, *Paris.*
U. J. Leverrier, *Paris.*
P. C. A. Louis, *Paris.*
Edward de Verneuil, *Paris.*

SWITZERLAND.

Alphonse De Candolle, *Geneva.*

ITALY.

Nicola Cacciatore, *Palermo.*
Gino Capponi.
Domenico Lo Faso, *Palermo.*
Macedonie Melloni, *Naples.*
Horatio Greenough, *Florence.*
Giovanni Plana, *Turin.*

BELGIUM.

A. Quetelet, *Brussels.*
Th. Schwann, *Louvain.*

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Joaquim Jose da Costa de Macedo, *Lisbon.*

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Don Angel Calderon de la Barca, *Washington.*
Señor Pascual de Gayangos, *Madrid.*

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Theod. Ludwig Wilhelm Bischoff, *Giessen.*
Leopold von Buch, *Berlin.*
Christian Gottfried Ehrenberg, *Berlin.*
Johann Friedrich Encke, *Berlin.*
Karl Friedrich Gauss, *Göttingen.*
Peter Andreas Hansen, *Gotha.*
Alexander von Humboldt, *Berlin.*
Karl Gustav Jacob Jacobi, *Berlin.*
Justus von Liebig, *Giessen.*
Bernhard von Lindenau, *Altenburg.*
Karl Franz Philip von Martius, *Munich.*
Johannes Müller, *Berlin.*
Karl Ritter, *Berlin.*
Heinrich Rose, *Berlin.*
Heinrich Christian Schumacher, *Altona.*
Friedrich Tiedemann, *Heidelberg.*

DENMARK.

Jans Christian Œrsted, *Copenhagen.*

SWEDEN.

Elias Fries, *Upsal.*

RUSSIA.

Karl Ernst von Baer, *St. Petersburg.*
Charles Cramer, *St. Petersburg.*
Michael Ostrogradsky, *St. Petersburg.*
Friedrich Georg Wilhelm Struve, *Pulkowa.*
G. Fischer de Waldheim, *Moscow.*

STATUTES

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

CHAPTER I.

Of Officers.

1. There shall be a President, a Vice-President, a Corresponding Secretary, a Recording Secretary, a Treasurer, and a Librarian, which officers shall be annually elected, by written votes, the day next preceding the last Wednesday in May.

2. If either of the Secretaries, the Treasurer, or the Keeper of the Library die, resign, or be removed during the year, the vacant office or offices shall, at the next meeting of the Academy, be filled, by written votes, for the remainder of the year.

CHAPTER II.

Of the President.

1. It shall be the duty of the President, and, in his absence, of the Vice-President or next officer in order, as above enumerated, to preside at the meetings of the Academy ; to summon extraordinary meetings of the Academy, upon any urgent occasion ; and to execute or see to the execution of the statutes of the Academy.

2. The President, or in his absence the next officer as above enumerated, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct. Bills presented on account of the Library or the publications of the Academy must be previously approved by the respective committees on these departments.

3. The President, or in his absence the next officer as above enumerated, shall nominate members to serve on the different committees of the Academy.

4. Any deed or writing, to which the common seal is to be affixed, shall be signed and sealed by the President, when thereto authorized by the Academy.

CHAPTER III.

Of the Secretaries.

1. The Corresponding Secretary shall keep the letter-book, shall record all letters written in the name of the Academy, and preserve on file all letters which are received; and, at each meeting, he shall read such letters as have been addressed to the Academy since the last meeting. With the advice and consent of the President, he may propose and make exchanges with such other scientific associations as he shall deem proper, and may give copies of the Transactions of the Academy for this purpose.

2. The Recording Secretary shall have charge of the charter and statute-book, journals, and all literary papers belonging to the Academy. He shall keep a record of the proceedings of the Academy at its meetings, and, after each meeting is duly opened by the presiding officer, he shall read the proceedings of the last meeting. He shall post up in the Hall a list of the persons nominated for election into the Academy, which list shall remain there at least during the interval between two successive quarterly meetings; and when any individual is chosen, he shall insert in the records the names of the Fellows by whom he was nominated.

3. The Corresponding and Recording Secretaries shall have authority to publish in an octavo form such of the proceedings of the Academy as may seem to them calculated to advance the interests of science.

4. It shall be the duty of the Corresponding Secretary, with the advice and consent of the President, to distribute copies of the Memoirs to Fellows of the Academy residing in foreign countries, as they shall deem expedient.

5. Any Fellow of the Academy shall be entitled to receive one copy of each volume hereafter published, by applying personally, or by written order, for the same within two years after such publication.

CHAPTER IV.

Of the Treasurer.

1. The Treasurer shall give such security as the Academy may require, for the trust reposed in him.

2. The Treasurer shall receive officially all moneys or sums of money due or payable, and all bequests or donations made, to the Academy; and, by order of the President or presiding officer, shall pay such sums as the Academy shall direct; and shall keep an account of all receipts and expenditures.

3. All moneys or sums of money, which there shall not be present occasion to expend, shall be put out at interest on such securities, or otherwise disposed of, as the Academy shall direct.

4. The Treasurer shall keep a separate account of the income and appropriation of the Rumford Fund, and report the same annually.

5. The Treasurer's accounts shall be annually audited by a committee appointed by the Academy for the purpose; it being understood that the committee chosen at the annual meeting in May shall act for the year immediately following the date of their election.

CHAPTER V.

Of the Library and Cabinet.

1. It shall be the duty of the Librarian to take charge of the books, to keep a correct catalogue of the same, and to provide for the delivery of books from the Library.

2. Any Fellow of the Academy may have at any one time three volumes from the Library.

3. Books may be kept out three calendar months, and no longer; and every person shall be subjected to a fine of twenty cents a week for every volume retained beyond that time.

4. Every person who takes a book from the Library shall give a receipt for the same to the Librarian or his assistant.

5. Every book shall be returned in good order, regard being had to the necessary wear of the book with good usage. And if any book shall be lost or injured, the person to whom it stands charged shall replace it by a new volume or set, if it belong to a set, or pay the current price of the volume or set to the Librarian; and thereupon the remainder of the set, if the volume belonged to a set, shall be delivered to the person so paying for the same.

6. All books shall be returned to the Library for examination, at least one week before the annual meeting. And every person then having one or more books, and neglecting to return the same, as herein required, shall forfeit and pay a fine of one dollar.

7. A Committee on the Library, to consist of three persons, of whom the Librarian shall be one, shall be chosen at the annual meeting in May. This committee shall examine the Library, and make report of its condition at the next annual meeting. They shall have authority to purchase such books, from time to time, as they may deem expedient; to make rules and regulations concerning the circulation, return, and safe-keeping of the books; and to appoint such agents for these purposes as they may think necessary. And for all these objects there shall annually be appropriated a proper sum, to be expended under their direction, and the charges to be made either to the Rumford Fund, or to that of the Academy, as the committee may direct.

CHAPTER VI.

Of Meetings.

1. There shall be annually four stated meetings of the Academy, namely, on the last Wednesday in January, the day next preceding the last Wednesday in May, the second Wednesday in August, and the second Wednesday in November, to be held at the Hall of the Academy in Boston.

2. The President shall have power to call extraordinary meetings of the Academy, at such time and place as he shall see fit.

3. Seven Fellows shall constitute a quorum for the transaction of business of every description which may come before the Academy.

4. The Recording Secretary shall notify the meetings of the Academy to the Fellows residing in Boston and the vicinity, and shall also cause the meetings to be advertised in the public papers, whenever he deems such further notice to be necessary.

CHAPTER VII.

Of Fellows.

1. No person shall be elected a Fellow of the Academy, unless proposed and recommended by one or more Fellows, who shall subscribe their names to the recommendation upon the nomination list. The name shall stand on the nomination list at least during the interval between two statute meetings previous to the election. Three fourths of the votes given shall be necessary to constitute a majority for the admission of a member ; and when three fourths shall amount to less than seven, then seven votes shall be necessary. Should any person, on balloting, not be admitted, his name shall be removed from the nomination list ; but may at any future period be placed upon it again for a new nomination.

2. Each Fellow residing in the State of Massachusetts shall pay annually two dollars to the Academy, and such additional sum, not exceeding three dollars, as the Academy at its annual meeting shall require.

3. Foreign Honorary Members may be chosen by the same vote as Fellows : but only at the statute meetings of May and November, and from a nomination list prepared by a Council for that purpose, and publicly read at the meeting immediately preceding that on which the balloting takes place. The Council for nominating Foreign Members shall consist of the President, Vice-President, the Secretaries, Treasurer, Librarian, and the members of the three standing committees, and no candidate shall be balloted for who is not recommended by the signatures of two thirds of the members of the Council.

CHAPTER VIII.

On Literary Performances.

1. The Academy will never express its judgment on literary or scientific memoirs or performances submitted to it, or included in its printed transactions.

2. A committee of three persons, to be called the Committee on Publications, shall be chosen at each annual meeting, and to them all memoirs submitted to the Academy shall be referred.

CHAPTER IX.

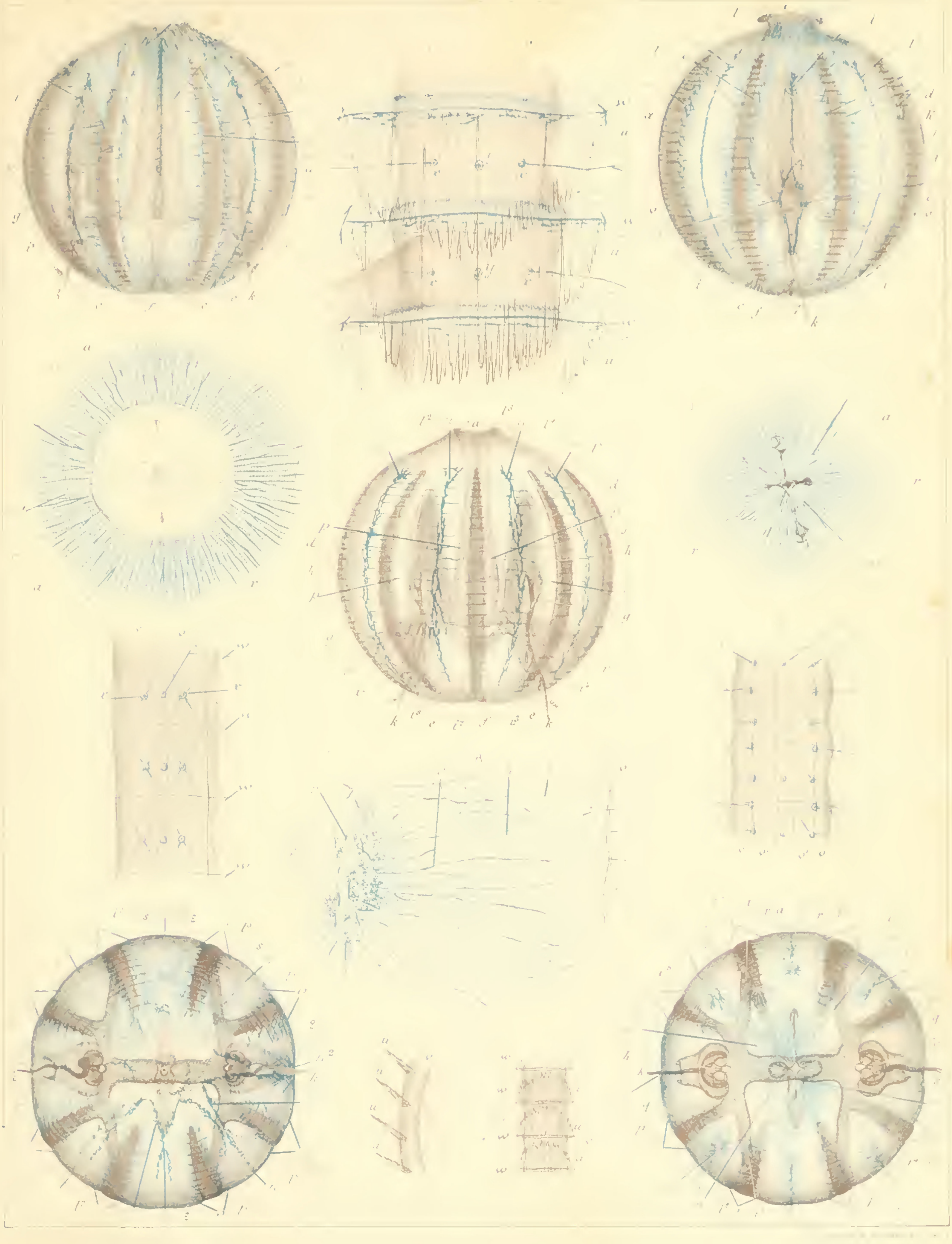
On Amendments of the Statutes.

All proposed alterations or additions to the statutes shall be referred to a committee during the interval between two statute meetings, and shall require for enactment a majority of two thirds of the members present, and at least eighteen affirmative votes.

RUMFORD PREMIUM.

In conformity with the last will of Benjamin Count Rumford, granting a certain fund to the American Academy of Arts and Sciences, and of a decree of the Supreme Judicial Court for carrying into effect the general charitable intent and purpose of Count Rumford, as expressed in his said will, the Academy is empowered to make from the income of said fund, as it now exists, at any annual meeting, an award of a gold and silver medal, being together of the intrinsic value of three hundred dollars, as a premium, to the author of any important discovery or useful improvement on light or on heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American islands ; preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind ; and to add to such medals, as a further premium for such discoveries and improvement, if the Academy see fit so to do, a sum of money not exceeding three hundred dollars.

For this purpose, a standing committee is appointed annually by the Academy, in May, to consider and report on all applications for the Rumford Premium.



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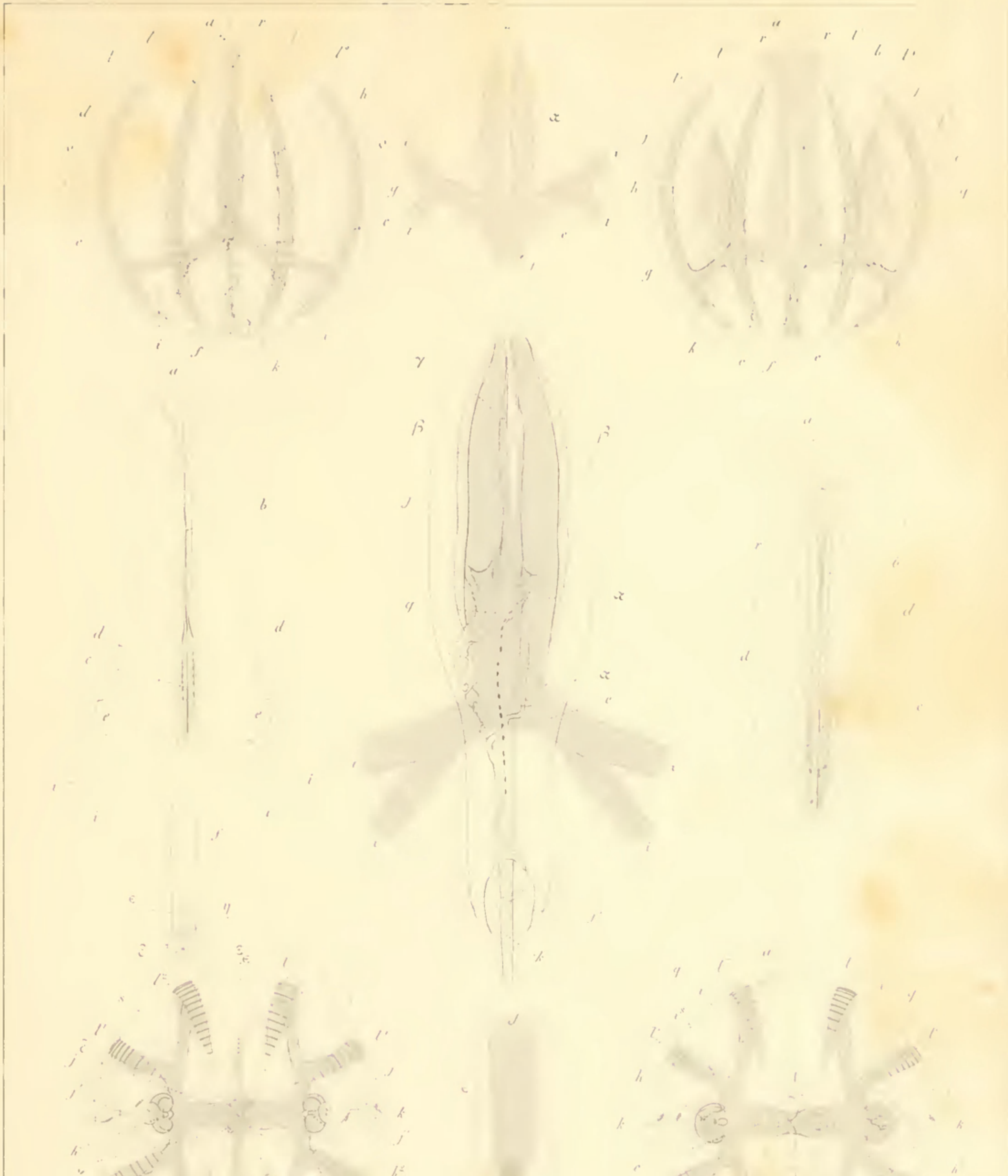

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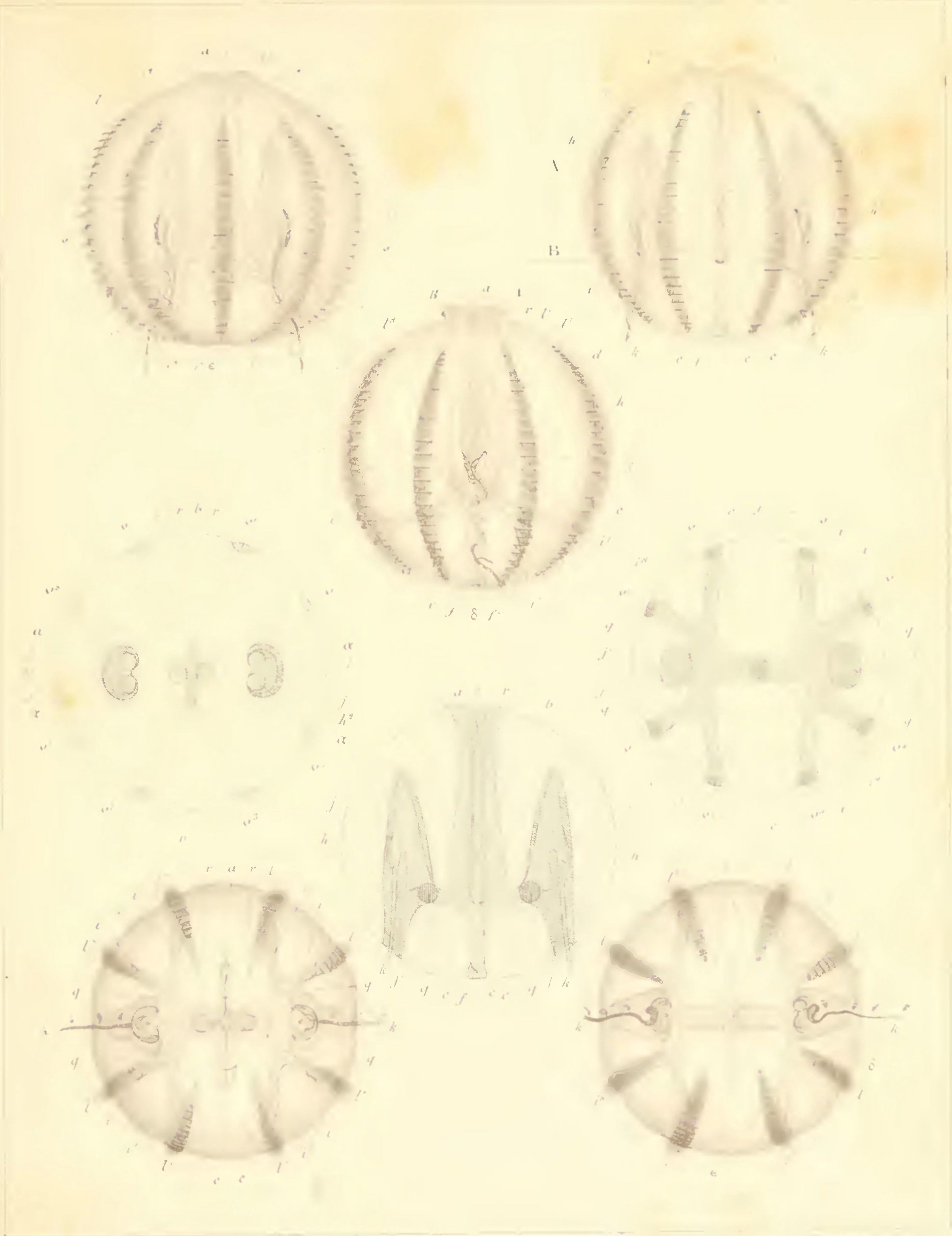

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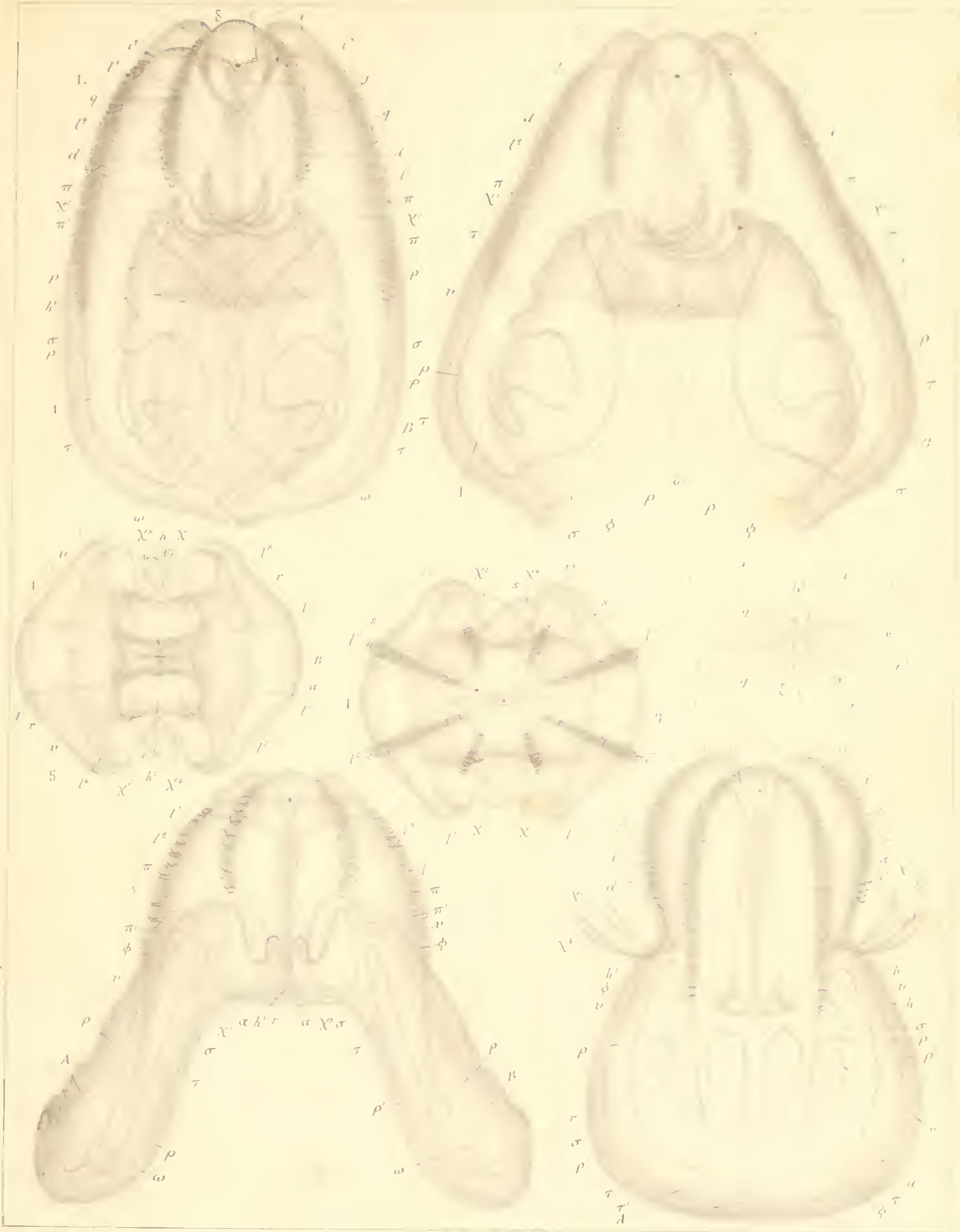
UROBRACHIA RHODODACTYLA Agas

BOLINA ALATA Ag.



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