The Cephalic Appendages of the Gymnosomatous Pteropoda, and especially of Clione.

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With Plate XXXV.

Eschricht formerly made known, on the three pairs of cephaloconi ("Kopfkegel") of Clione borealis, some structures which he described and represented as real suckers; at the same time he drew attention to the analogy of their situation with that of the suckers of the Cephalopoda.[1]

This fact was of great importance, since it accorded with the presence of suckers on the two buccal appendages of another Gymnosomate, viz. Pneumodermon, and gave great support to the opinion expressed by R. Leuckart, that the six conical appendages of the head of Clione correspond with the arms of the Cephalopoda.[2]

From that time the assertion that Clione possesses acetabuliferous appendages has been admitted everywhere, and it is found reproduced in the most valuable and most recent works.

However, the excessive smallness of the structures which Eschricht had described as suckers (he attributes to them 0·005‴ of diameter) permitted one to call in question their assimilation with the suckers of Pneumodermon and of the

[1] Eschricht, 'Anatomische Untersuchungen über Clione borealis,' p. 9.

[2] R. Leuckart, 'Ueber die Morphologie und die Verwandschaftsverhältnisse der Wirbellose Thiere.'

Cephalopoda, the more so as Hobböll, who has observed Clione living, and has often seen their cephaloconi expanded, has never remarked that these animals fixed themselves by these appendages,[1] while several naturalists have seen Pneumodermon in life, and have noticed that it frequently fixes itself with the aid of its acetabuliferous appendages.

Therefore, during the sojourn which I made in the winter of 1884-85 at the zoological laboratory of University College (London), Professor Ray Lankester proposed to me to study the structure of the cephaloconi of Clione.

Having set to work, I immediately saw that in a large number of well-known and even very recent works great confusion prevailed on the cephalic appendages of Clione. The reason of this is specially to be found in the imperfection of the original figures, which are generally obscure on the subject; and those which are most often reproduced are just the most defective,[2] for they give a very bad idea of the cephalic appendages of Clione, or are even absolutely incomprehensible on this point.

Those of Eschricht are small, and also difficult to understand, so that the reproductions which have been made of them are inexact, and, as Keferstein has remarked, "all those processes which have been named tentacles by Eschricht want a new description."[3]

When I had comparatively examined other Gymnosomata, I remarked that there also a confusion quite as great existed on the cephalic appendages, the more so since the original authors do not agree on this question.

In order to dispel the confusion which exists on this subject, I have thought useful to represent on a rather large scale, and under different aspects, the cephalic part of some

[1] Eschricht, loc. cit., p. 9.

[2] For example, the figure of Clione given by Rang (Rang et Souleyet, 'Histoire naturelle des Mollusques Ptéropodes,' pl. vii, fig. 9), reproduced by Keferstein (Bronn's 'Thierreich'), by Claus ('Elementary Text-Book of Zoology'), &c.

[3] Keferstein, Bronn's 'Thierreich,' Abth. iii, p. 613.

Gymnosomata. I thus have been induced to extend to the cephalic appendages of the gymnosomatous Pteropoda a work specially undertaken to make known the structure of the cephaloconi of Clione.

This paper is divided into three parts, corresponding to the different genera which I have studied: Clione, Clionopsis, and Pneumodermon.

I. Clione.[1]

Clione (Pl. XXXV, figs. 1—4) possesses two kinds of cephalic appendages:

1. Tentacles properly so called.
2. Cephaloconi or buccal cones.

I shall examine successively these two orders of appendages.

A. Tentacles properly so called.

Clione possesses two pairs of them—an anterior or labial pair, and a posterior or nuchal pair.

Anterior Pair.—It is situated on a hood, whose two halves, right and left, may fall back laterally, or be joined together again on the antero-posterior mesial line, and hide the buccal opening and the three pairs of buccal cones. These tentacles are long and retractile. They are not absolutely anterior, as in the figure of Eschricht, which represents them as equally distant from the dorsal and ventral faces;[2] they are situated nearer the dorsal than to the ventral face, as shown in Plate XXXV, fig. 2.

Very powerful longitudinal muscles occupy the whole of the interior part of these appendages; externally, we find a thin layer of annular muscular fibres. The epithelium is like that of the other parts of the body; their cells are cylindrical and provided with a large nucleus.

Sections which pass towards the free extremity of these tentacles show a rather large number of nervous cells, but I have

[1] The species studied is Cl. limacina, Phipps, = Cl. borealis, Pallas.

[2] Eschricht, loc. cit., Taf. 2, fig. 10.

not seen any special nervous terminations, such as we shall find on the buccal cones.

Posterior Pair.—It is situated on the dorsal face of the neck. These tentacles are much shorter than those of the first pair. Upon the animals preserved in spirit they are always retracted, so that they are difficult to see, their presence being then disclosed only by two slight recesses, from which their extremities are sometimes seen emerging under the form of a white point.

According to Eschricht, this second pair is oculiferous ;[1] but this fact has been called in question by several naturalists, and categorically denied by von Ihering.[2]

The histological examination which I have made of the nuchal tentacles of Clione, Clionopsis, and Pneumodermon, allows me to assert that these appendages do present eyes at their free extremity.

Unfortunately the specimens which have served me in my researches had not been specially prepared for the study of the nervous system and of nervous terminations as delicate as the retinal ones. It follows that I can neither draw nor describe in a complete manner the structure of the eyes of the Gymnosomata. That is a point which I intend to take up as soon as possible.

Nevertheless, the profound dissimilitude which I have observed between the labial and nuchal tentacles, and the characters of the structure of the latter in the three species which I have studied, show that the nuchal tentacles are quite different from those of the first pair, and the presence of a refracting body shows that the sense of which they are the seat is that of sight.

At the free extremity of these tentacles, the epithelium becomes much thinner, so as to make a pellucida or cornea. Under this membrane we find a spherical lens, of which the structure is similar to that of the Pulmonata. As I have

[1] Eschricht, loc. cit., taf. 3, fig. 29.

[2] Von Ihering, 'Vergleichende Anatomie der Nervensystem und Phylogenie der Mollusken,' p. 240.

already said, the retinal part is not perfect in any section, but its position and general form recall to mind those of the retina of the Gastropoda. In the specimens of Clione the pigment had disappeared, but in those of Pneumodermon it was preserved. Finally, towards the base of the tentacle the nerve traverses an optic ganglion.

B. Buccal Cones.

They number three pairs, symmetrically situated on the two sides of the "lips." The two dorsal cones are the longest, the two ventral cones the shortest (fig. 3).

These cones are very extensible, and in the state of expansion they are much longer than they are generally represented. They are absolutely conical, as my figures show them, which I made from specimens[1] of the "Challenger," preserved with the extended cones and all the appearances of the living animal.

These cones are brightly coloured during life. They are inserted on the two sides of the "lips" as shown in fig. 4.

They are hollow in their lower half, and their cavity is continuous with that of the head, which includes the buccal mass and the penis. Examining these cones with a magnifying glass, one sees that they are covered with innumerable very small tubercles, which have been described by Eschricht as so many groups of suckers.

Structure of the Buccal Cones.

On any section of a buccal cone of Clione we may easily distinguish three different regions:

1. A middle, muscular region formed of two parts: *a*. an exterior layer with annular fibres (fig. 11, *a*); *b*. an interior layer with longitudinal fibres (fig. 11, *a'*).
2. An internal region formed of glandular cells (fig. 11, *b*).
3. An external region, or epithelial clothing (fig. 11, *c*).

[1] Mr. John Murray, F.R.S.E., Director of the Challenger publications, kindly supplied Professor Lankester with these specimens as soon as he heard that Clione was undergoing investigation in the laboratory of University College.

I shall examine these different parts successively.

1. Muscles of the Buccal Cones.—The muscular cells are unstriped, elongated, and contain a nucleus of a prismatic form (fig. 13, *b'*). The muscular external layer of annular fibres is much less developed than the internal layer. This latter is very powerful, which explains the great extensibility of the cones. The longitudinal fibres are united in distinct groups (fig. 13, *b*).

2. Glandular Internal Cells.—A transversal section of one of the cones shows that their interior is filled with cells united in groups (fig. 11, *b*). In the lower half of the cone the centre of the sections is empty, and the cells are only found against the longitudinal muscular layer.

A longitudinal section will make this disposition better understood (fig. 12). The cells in question are united in elongated groups, having the form of follicles. Each cell possesses a proper prolongation, which is continued to the epithelial covering of the cone. Each of these groups possesses a basement membrane of connective nature, but the different groups are pressed one against the other without one being able to see between them any free connective tissue, under the form of cells or fibres. The spaces which are seen in several places, on the figure 10 of the plate, proceed from displacements which occur during the preparation of the sections. Among the groups which have been displaced I have not seen any traces of connective tissue.

These groups of secreting cells do not constitute a gland, for nowhere on any section, longitudinal (fig. 16) or transversal (fig. 17), can a lumen be seen, nor efferent duct. Each cell is an independent unicellular gland. The contents of these cells is a slightly granular substance. The nucleus is large and spherical; it gives indications of its reticulated structure, but not clearly enough to make drawings of them showing this structure.

The cells situated at the interior extremity of the groups have excessively long prolongations (fig. 16, *d*); the cells situated near the muscular layer have, on the contrary, much

shorter ones. When these prolongations arrive at the longitudinal muscular layer their contents change their appearance and present themselves under the form of a fibroid secretion (fig. 18, *c*) which absorbs much hæmatoxylin. These fibroid prolongations pass between the groups of longitudinal muscular fibres (*d*, fig. 13), traverse the layer of circular muscles, and pass into the reticulum of subepithelial connective tissue; afterwards each prolongation penetrates into an epithelial cell, which it traverses by passing between the membrane and the cellular contents.

3. Epithelial Investment.—This is the most characteristic part of the buccal cones of Clione. The epithelial cells are united in a variable number, so as to form an infinity of small circular groups on the surface of the cones. It is these small groups which give to the cones their rugose or wrinkled aspect.

A transversal or longitudinal section shows that these groups, pressed one against the other, cover the whole surface of the cone, and that each group is formed of a little elevation upon which the epithelial cells are found.

Examining one of these groups with an ordinary magnifying power (Verick, obj. 6) we see that the space between the annular muscular fibres and the epithelial cells is occupied by a reticulum of connective tissue which unites the two above-named elements.

The epithelial cells (fig. 13, *f*) are elongated, nearly cylindrical, but wider towards their lower part. They are separated from one another at their higher part, and end at their free extremity in a button-like enlargement.

The cellular contents (*h*) have nearly the form of the cell. At the lower part the contents have the form of a club, the big end of which would be turned towards the bottom; at the higher part the contents fill exactly the terminal enlargement.

This cellular substance is finely granular, but does not comprise any nucleus.

The cellular membrane is rather thick and presents, in its

thickness, longitudinal striæ which are strongly coloured by the hæmatoxylin.

Between the cellular substance and the membrane we find the fibroid secretion (*d*) of the glandular cells which occupy the interior of the cone.

Each of the epithelial cells so constituted has been taken by Eschricht for a sucker.

Under each epithelial group, at the surface of the annular muscular layer, or even between the fibres of the latter, is found a large sensorial cell (*i*), which sends a prolongation (*k*) across the subepithelial connective tissue. This prolongation continues between the epithelial cells and terminates freely at the surface of the cone.

These sensorial cells possess a large refracting nucleus (*j*), with a strongly colourable nucleolus.

The prolongation, rather narrow in the connective tissue, enlarges a little between the epithelial cells and constitutes a rod in the form of an elongated cone (*l*), with the base turned towards the surface. The part of the prolongation, contained in the connective tissue, presents in some series of sections strongly coloured, a very special aspect; it appears to be reticulated (fig. 14, *a*). The conical part, situated between the epithelial cells, presents numerous longitudinal striæ. The rod is terminated by a kind of small horizontal rather thin disc (fig. 13, *m*), which is more strongly coloured than the subjacent part. This disc does not bear cilia such as we see upon the extremity of some sensorial cells. I do not think that in the specimens I have studied, the sensorial cells have lost their ciliary covering, for the other parts of the body which bear ciliæ have their ciliary investment intact.

At the prolongation of the sensorial cell, towards the base of the epithelial cells, we find a spherical or ovoid refracting body (*n*) joined to it, whose membrane seems rather thick, and in the interior of which we find a corpuscle deeply coloured by the hæmatoxylin.

The complicated structure of these epithelial groups is very clearly shown by a series of transversal sections of these groups,

that is to say, by sections made tangentially on the surface of the cone. Such sections are difficult to obtain exactly, but when they are in the direction wished for, they are very instructive.

I represent four of these sections, which I shall describe successively, passing from the base to the free extremity.

1. Section passing above the annular muscular layer (fig. 19). We see the sensorial cell (*a*) in the middle of the reticulated connective tissue (*b*), in which we find also fibroid prolongations (*c*) of the internal glandular cells.

2. Section passing through the base of the epithelial group (fig. 20). Here we see the prolongation (*a*) of the sensorial cell, the continuation of the fibroid prolongations (*c*), and the surrounding connective tissue (*b*).

3. Section passing through the extreme base of the epithelial cells (fig. 21). We find the rod (*a*) at the centre, with the refracting body (*b*), which is joined to it. All around are the bases of the central epethelial cells (*c*), in the interior of which we see the fibroid secretion (*d*) of the internal glandular cells. At the external part one sees connective tissue (*e*).

4. Section passing through the epithelial cells (fig. 22). The external cells are already separated from their neighbours. We see in the middle the section of the rod (*a*), of which we distinguish the striated structure. In the membrane (*b*) of the epithelial cells we find some coloured points (*c*), indicating the sections of the longitudinal striæ in this membrane, which I have already described.

Summary.—What Eschricht has taken for suckers are epithelial cells terminated by a button-like enlargement. It is noticeable that there is no nucleus to be observed in these cells. Besides, they are penetrated by the secretion of the glandular cells which occupy the interior part of the cone. The latter are so numerous (apparently as numerous as the cells of the epithelial groups) that they doubtless fulfil important functions. I think that their secretion is spread outside of the cone across the button-like extremity of the epithelial cells, for on some specimens of which the epithelium

has remained quite intact this secretion had spread outwardly, had become coagulated under the influence of the spirit, and had formed a stratified deposit, which absorbs much colouring matter on the surface of the cone.

Each group of epithelial cells is provided at its centre with a sensorial cell with a rod-like prolongation. This fact determines the buccal cones of Clione as organs of special sensibility. A refracting body is invariably found towards the central part of the epithelial groups at the base of the cells; it is also probably, on account of its situation in contact with the rod, an integral part of the sensorial apparatus.

With respect to the special nature of these organs, I may make a remark with reference to the sense of smell in aquatic animals. Is smelling possible in water, such as exists among the superior Vertebrata? I do not think so. There must be a special sense of which Mammalia cannot be conscious; and a truly aquatic animal cannot have an idea of the smelling of aërial animals. This sense must be a peculiar one, intermediate to that of smell and that of taste. The buccal cones of Clione are probably the seat of such a sense.

II.—Clionopsis.[1]

Clionopsis only possesses one kind of cephalic appendages—tentacles properly so called.

As with Clione, there are two pairs—a labial pair and a nuchal pair (fig. 5).

The labial tentacles are less elongated than with Clione. As in the latter they are inserted more dorsally than ventrally. Their structure is that of the corresponding appendages of Clione.

The nuchal pair has already been described by Troschel.[2] Gegenbaur says that it is absent.[3] Upon the specimen which

[1] The species studied is Clionopsis Krohni, Troschel, = Clio. mediterranea, Gegenbaur.

[2] Troschel, "Beiträge zur Kenntniss der Pteropoden," 'Arch. für Naturg.,' 1854, p. 229.

[3] Gegenbaur, 'Untersuchungen über Pteropoden und Heteropoden,' p. 70, Taf. iv, fig. 14.

I have studied the nuchal tentacles were extended and very easily visible. Their structure is that of the nuchal tentacles of Clione. The eyes are not situated near the tentacles, as Troschel says,[1] but on their top.

Clionopsis does not possess any other cephalic appendages. The lips open into a narrow buccal cavity, and do not form a hood which can fall back, as with Clione.

III. Pneumodermon.[2]

Pneumodermon is provided with two kinds of cephalic appendages:

1. Tentacles properly so called, corresponding to those of Clione and Clionopsis.

2. Two acetabuliferous buccal appendages, characteristic of the genus (figs. 8, 9).

A. Tentacles properly so called.

Like Clione and Clionopsis, Pneumodermon possesses two pairs of tentacles, a labial pair and a nuchal pair.

As with the two preceding genera, the labial tentacles are found situated on the two sides of the mouth, rather dorsally.[3]

The nuchal pair has already been described by Souleyet.[4] Gegenbaur asserts that the first pair is the only one which exists.[5] The second pair is, indeed, very difficult to see, being retracted in the preserved specimens, the recesses which result from it being imperceptible; however, this place is less coloured than the adjacent parts. By making some transversal sections in the anterior part of Pneumodermon, I

[1] Troschel, loc. cit., pl. x, fig. 9, *o*.

The species which I studied are: Pneumodermon mediterraneum, van Ben., and P. Peronii, Lam.

[3] Figure 7 may be applied to Pneumodermon as well as to Clionopsis. Besides Souleyet ('Zoologie du voyage de la Bonite,' pl. xv, fig. 15) has already very well represented this aspect of Pneumodermon.

[4] Loc. cit., vol. ii, p. 256, and pl. xv, fig. 14.

[5] Gegenbaur, loc. cit., p. 24.

have been able to assure myself with certitude that the second pair of tentacles positively exist in this genus, as with Clione and Clionopsis. But I have not remarked that they had the bifid form indicated by Souleyet.[1] These tentacles bear at their free extremity an eye, which has the same structure as those of the two preceding genera.

B. Acetabuliferous Buccal Appendages.

These appendages are inserted on the internal wall of the buccal cavity, on the ventral side. Two figures of Souleyet show this disposition perfectly (loc. cit., pl. 15, figs. 17 and 30); fig. 17 has been badly understood by Fischer, who gives the two groups of suckers for the jaws.[2]

The acetabuliferous appendages of Pneumodermon have the form of a flattened cylinder, upon which are inserted the peduncles of the suckers. These vary in number according to the species. Pneumodermon Peronii possesses a large number of them, about thirty on each appendage; P. violaceum, ten to fourteen on each appendage, and P. mediterraneum five or six. However, in this last species I have sometimes found seven suckers, but then one or two were very small.

In the state of inactivity the suckers have the form of a very flat porringer. It is in P. mediterraneum that I saw the largest; they were one line in diameter.

Structure of the Acetabuliferous Buccal Appendages.

It does not at all resemble that of the buccal cones of Clione. The whole of its mass is formed by longitudinal muscular fibres. Externally we find a uniform epithelium; that is to say, it is not provided with sensorial cells like the epithelium of the cones of Clione. The buccal appendages of Pneumodermon are not, then, sensorial organs, as some

[1] Loc. cit., vol. ii, p. 256.
[2] Fischer, 'Manuel de Conchyliologie,' fig. 42, p. 44.

authors say.[1] Moreover, there is nothing in these appendages which recalls to mind the internal glandular mass of the cones of Clione.

Structure of the Suckers.

The only histological knowledge of these organs which we formerly possessed proceeds from Gegenbaur's researches, who attributes a very simple structure to them.[2] But this knowledge was not very extensive.

During the month of January, 1885, I studied the structure of these suckers by means of a series of transversal sections. I had scarcely finished this study when I received the thesis of Niemiec, "Recherches morphologiques sur les ventouses dans le règne animal."[3] In this work the structure of the suckers of Pneumodermon is carefully described and represented. My own observations agreeing almost entirely with those of the Swiss zoologist, I believe it useless to explain them at length. Hence I refer to the memoir of Niemiec, limiting myself to the principal points relative to the structure of the sucker and to indicating a few points of detail in which I do not entirely agree with the Swiss zoologist.

The body of the sucker is formed of a layer of large, prismatic, muscular cells (figs. 24 and 25), the contents of which are formed of different separated fasciculi of fibres (*a*). These fasciculi have the form of very flat, three-sided prisms, of which the most acute angle is turned towards the centre of the cell. In this place we find the nucleus (*b*), which has a shape analogous to that presented by the nucleus of the muscular cells of the cones of Clione. All around, towards the upper side of the disc formed by this layer of prismatic cells, we find a sphincter formed of not very numerous annular muscular fibres. The upper face of the muscular disc is covered with a pavimentous epithelium (fig. 23, *c*) with excessively flattened cells, whose nucleus is consequently excessively flat.

[1] Claus, 'Handbuch der Zoologie,' French translation, p. 1056.
[2] Gegenbaur, loc. cit., p. 77.
[3] 'Recueil zoologique suisse,' t. ii, 1885.

Between this epithelium and the prismatic muscular cells we see absolutely no connective tissue. On the upper side of the disc, outside the sphincter, the epithelial lining thickens very much, which is explained by the fact that it is by this part that the adherence of the sucker to foreign bodies is produced.

I have not remarked the constant presence of the cuticular pads ("bourrelets") which Niemiec described.[1] Perhaps these parts are specially visible in suckers of large size.

Beneath the epithelial thickening of which I speak, we find, all around the disc, glandular cells in the form of a flask with a very narrow neck. The efferent duct of these cells traverses the epithelial thickening and passes out at the upper face of the exterior ring of the sucker, that is to say, on the point where the adherence is produced. The secretion of these cells probably makes this adherence more perfect.

On the lower face of the sucker the epithelium is less flattened than on the upper face, and it is united to the prismatic muscular cells by connective tissue.

The peduncle is covered with an epithelium continuous with that of the upper face of the sucker, and quite analogous to it. The peduncle itself is formed by the continuation of the longitudinal muscular fibres of the buccal appendage. These fibres turn to the lower part of the acetabular disc.

According to Niemiec, some fibres of the peduncle go to the side of the sucker. Such fibres I have not observed. In my opinion the longitudinal muscular fibres of the peduncle (fig. 23, *a*) only go to the central part of the disc, and are inserted on it, between two prismatic muscular cells, by their extremity, which ends in a point (*b*). A retracting muscle inserted on the side of the sucker would be far from having a useful effect. Since it is at this point that the adherence is produced, the action of such muscles could only tend to combat it, while the muscles inserted on the centre of the sucker, by removing this point from the body to which the circumference

[1] Loc. cit., pl. iii, fig. 2, *c*.

of the disc adheres, augment the vacuum under this disc, and consequently the adherence.

Except this point of detail, I quite agree with Niemiec on the physiological mechanism of the suckers of Pneumodermon. I am specially persuaded that the prismatic muscular cells fulfil an important part during the first moments of fixation. These cells are especially worthy of the attention of those who are interested in the comparative study of different forms of muscular tissue.

Cirrifer.

In 1879, G. Pfeffer described by this name a gymnosomatous Pteropod, which much resembles Pneumodermon, whose caudal and lateral gills it possesses.[1]

This Pteropod bears two buccal appendages like Pneumoderma, but instead of being provided with suckers these two appendages are terminated by two small branches bent round in the form of a sickle. According to the drawing of Pfeffer, these appendages differ further from those of Pneumodermon, in that they are not inserted separately on the buccal wall, but reunite in a common stem before arriving at that wall.

Pfeffer describes two superior or labial tentacles; it is very probable that the nuchal tentacles, very small and retracted, have escaped him, as those of Pneumodermon have escaped Gegenbaur.

Summary.

The different authors agree but little on the cephalic appendages of the gymnosomatous Pteropoda, and many of them consider all these appendages as tentacles. In short their homologies are very obscure.[2]

We have stated that in the Gymnosomata there exists in a constant manner two pairs of tentacles properly so called. I

[1] 'Monatsberichte der Akad. der Wissensch.,' Berlin, 1879, p. 249, fig. 20.

[2] "The connections between these conformations and the tentacles of the Gastropoda are not yet very clear," Gegenbaur, 'Grundzüge der Vergleichenden Anatomie,' French translation, p. 481.

do not think it will be rash to identify these appendages with the two pairs which the Gastropoda Euthyneura (Opisthobranchia and Pulmonata) possess, and which occupy the same position among these animals as with the Gymnosomata.

In the Thecosomata we find a pair of rudimentary tentacles, for example, in Hyalaea, Cleodora, and Creseis,[1] Cuvieria and Spirialis,[2] Tiedemannia[3] and Cymbulia.[4]

With several of these animals the tentacles present rudimentary eyes, Creseis for example.[5]

If they do not present eyes in the adult state they possess them in some stage of the development, as in Tiedemannia and Spirialis.[6]

This pair of tentacles is, in my opinion, equivalent to the oculiferous nuchal pair of the Gymnosomata. As to the anterior pair, its disappearance is explained by the displacement of the swimming lobes, which encircle the head and between which the mouth opens. The development of the fins in this position has caused the disappearance of the anterior tentacles.

Besides the two pairs of tentacles properly so called, we have seen that most of the Gymnsomata possess buccal appendages; such are Clione, Pneumodermon, Cirrifer.

Without prejudging anything as to the morphological value of these appendages, I believe that they have the same origin, however varied their aspect may be in the three genera above named.

Apparently it seems that with Clione they are inserted around the mouth, while with Pneumodermon and Cirrifer they are inserted on the internal wall of the buccal cavity. But it should be noted that in Clione there exists a hood which can fall back. This hood covers the buccal cones, and its opening corresponds to the buccal opening of Clionopsis,

[1] Gegenbaur, 'Untersuchungen über Pteropoden,' p. 8.

[2] Souleyet, loc. cit., vol. ii, pp. 199 and 209, pl. xii, fig. 32, and pl. xi, fig. 15.

[3] Gegenbaur, loc. cit., p. 60.

[4] Gegenbaur, loc. cit., p. 45.

[5] Gegenbaur, loc. cit., p. 8, Taf. ii, fig. 1.

[6] Kröhn, 'Beiträge zur Entwickelungsgeschichte der Pteropoden,' p. 21.

Pneumodermon, and Cirrifer (compare figs. 2, 4, and 7) The "lips" situated between the cones of Clione are not then equivalent to the lips of the other Gymnosomata, in which there is no developed hood like that of Clione. They would be a differentiation of the internal wall of the buccal cavity, which is produced behind the buccal appendages.

In this manner we see that with Clione, as with Pneumodermon and Cirrifer, the buccal appendages are inserted on the internal wall of the buccal cavity.

At the same time it must be remembered that this front portion of the buccal cavity may be regarded as not part of the true oral cavity, but as only an "introvert" like that of proboscidiferous Gastropods.

EXPLANATION OF PLATE XXXV.

Illustrating Dr. Paul Pelseneer's Paper on "The Cephalic Appendages of the Gymnosomatous Pteropoda, and especially of Clione."

FIG. 1.—Head of Clione. Dorsal aspect. *a*. Labial tentacles. *b*. Nuchal tentacles. *c*. Buccal cones. *d*. Fins. *e*. "Lips." *f*. Edge of the hood.

FIG. 2.—Head of Clione. Oral view, the hood being nearly closed. *a*. Labial tentacles. *c*. Buccal cones. *f*. Edges of the hood.

FIG. 3.—Head of Clione. Lateral view. *a*. Labial tentacle. *b*. Nuchal tentacle. *c*. Buccal cones. *d*. Fin. *e*. Foot. *f*. Edge of the hood. *g*. Orifice of the penis.

FIG. 4.—Head of Clione. Oral view, the hood being open. *a*. Labial tentacles. *c*. Buccal cones. *d*. "Lips." *f*. Edge of the hood.

FIG. 5.—Head of Clionopsis. Dorsal aspect.

FIG. 6.—Head of Clionopsis. Lateral view. *a*. Labial tentacles. *b*. Nuchal tentacles. *c*. Foot. *d*. Fins. *e*. Orifice of the penis.

FIG. 7.—Head of Clionopsis. Oral view. *a*. Labial tentacles. *b*. Mouth. *c*. Lips.

FIG. 8.—Head of Pneumodermon. Dorsal aspect.

FIG. 9.—Head of Pneumodermon. Lateral view. *a*. Labial tentacles. *b*. Nuchal tentacles. *c*. Acetabuliferous buccal appendages. *d*. Fins. *e*. Lips. *f*. Foot. *g*. Orifice of the penis.

FIG. 10.—Head of Creseis. Dorsal aspect. (After Gegenbaur.) *a*. Mouth. *b*. Tentacles with eyes. *c*. Foot. *d*. Fins. *e*. Mantle.

FIGS. 11—22.—Clione.

Fig. 11. Transverse section of a buccal cone. *a*. Annular muscular layer. *a'*. Longitudinal muscular layer. *b*. Internal glandular cells. *c*. Epithelial covering.

Fig. 12. Longitudinal section of a buccal cone. Letters as in Fig. 11.

Fig. 13. An epithelial group of the section Fig. 11, more magnified. *a*. Annular muscular layer. *b*. Longitudinal muscular layer. *b'*. Nucleus. *c*. Internal glandular cells. *d*. Their fibroid secretion. *e*. Reticulated connective tissue. *f*. Epithelial cells. *g*. Its button-like termination. *h*. Cellular contents. *i*. Sensorial cell. *j*. Its nucleus. *k*. Its rod-like prolongation. *l*. The striated conic part of the rod. *m*. The terminal disc of the rod. *n*. Refracting body.

Fig. 14.—An epithelial group, showing the reticulated aspect of the rod of the sensorial cell. *a*. Prolongation of the sensorial cell. *b*. Striated part of the rod. *c*. Refracting body. *d*. Epithelial cells. *e*. Fibroid secretion of the internal glandular cells.

Fig. 15.—An epithelial cell, showing the striæ of the membrane. *a*. Striæ of the cellular membrane. *b*. Cellular contents. *c*. Fibroid secretion.

Fig. 16.—Longitudinal section of a group of glandular cells of the interior of a buccal cone. *a*. Internal glandular cells. *b*. Its nucleus. *c*. Basement membrane. *d*. Prolongation of the glandular cell.

FIG. 17.—Transversal section of several groups of internal glandular cells. *a*. Glandular cells. *b*. Nucleus. *c*. Basement membrane.

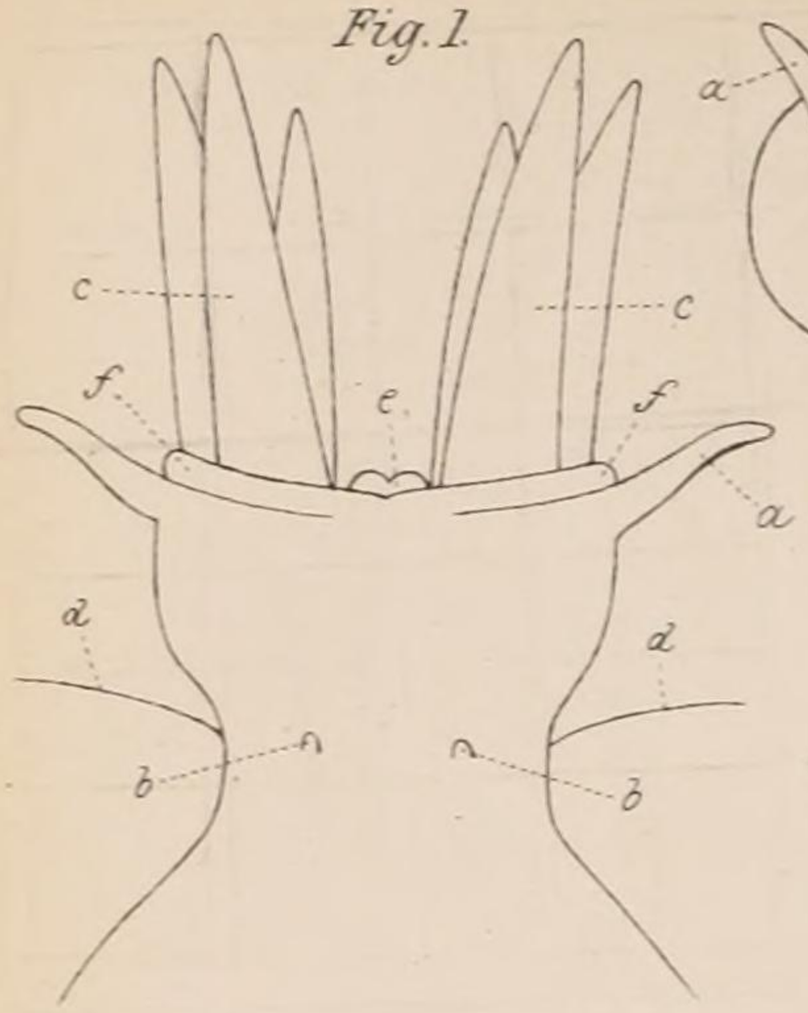
FIG. 18.—A glandular cell adjacent to the muscular part of the cone, showing the passage of the cellular substance to the fibroid secretion. *a*. Nucleus. *b*. Cellular contents. *c*. Fibroid secretion.

FIG. 19.—Transverse section of an epithelial group, passing a little above the annular muscular layer. *a*. Sensorial cell and its nucleus *b*. Reticulated connective tissue. *c*. Fibroid secretion of the internal glandular cells.

Fig. 20. Ditto, through the base of the group. *a*. Prolongation of the sensorial cell. *b*. Reticulated connective tissue. *c*. Fibroid secretion of the internal glandular cells.

Fig. 21. Ditto, through the extreme base of the epithelial cells. *a*. Prolongation of the sensorial cell. *b*. Refracting body. *c*. Base of the central epithelial cells. *d*. Fibroid secretion. *e*. Connective tissue.

Fig. 1.



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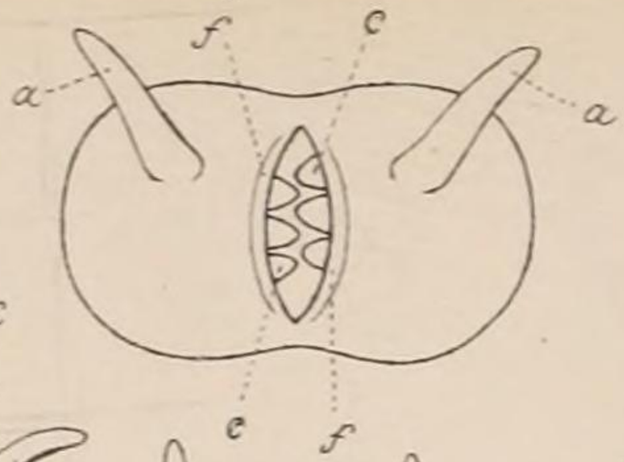

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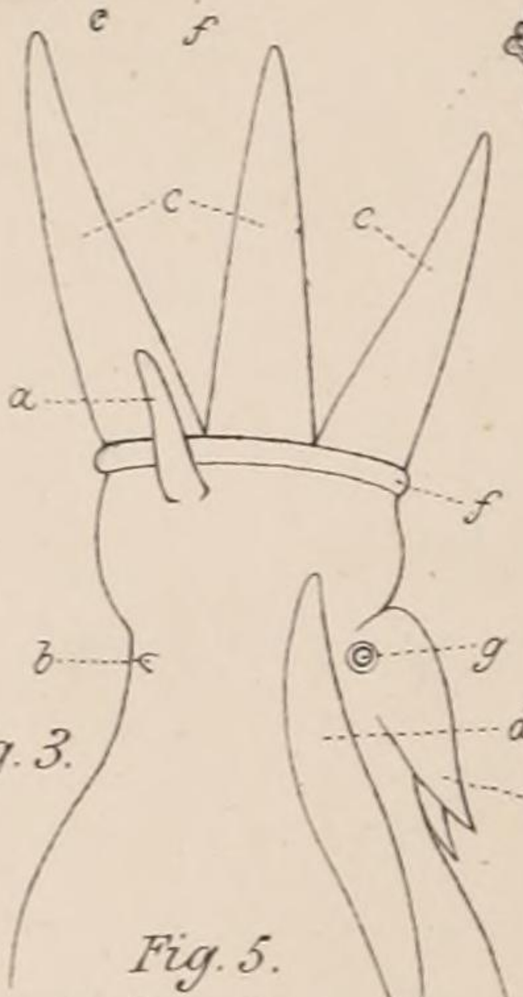

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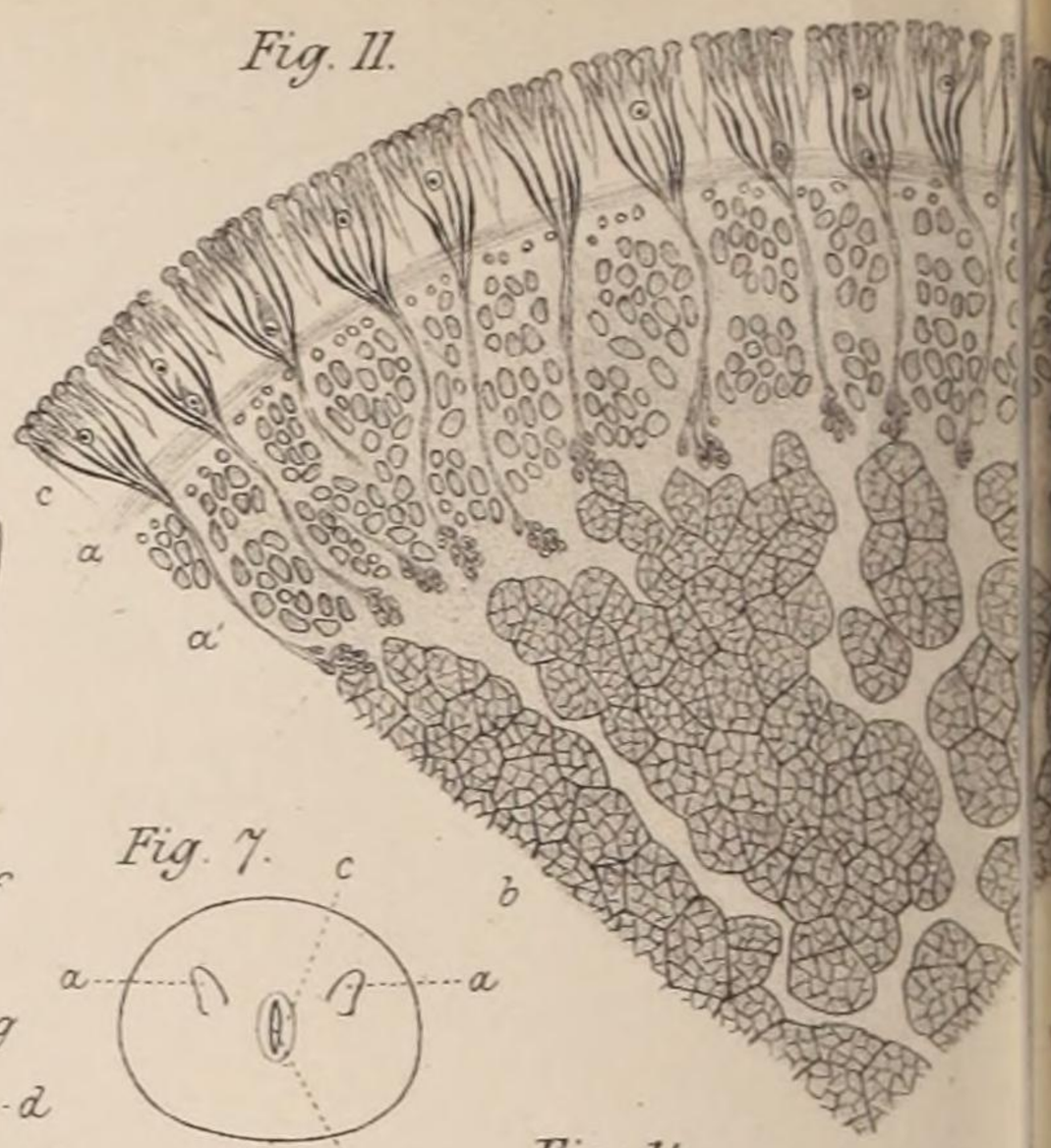

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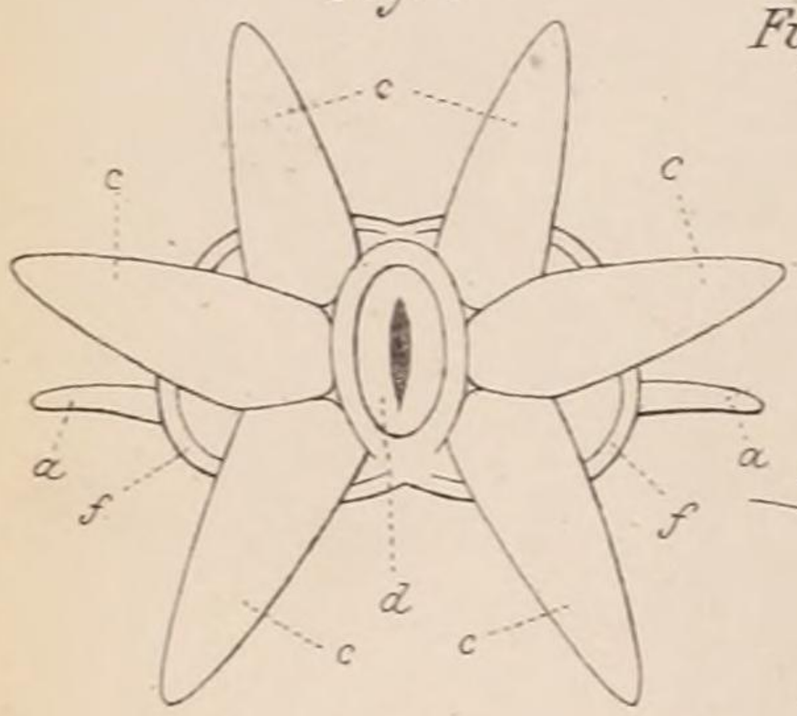

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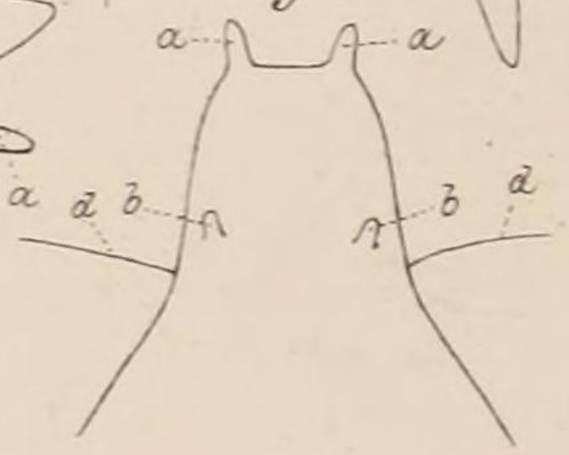

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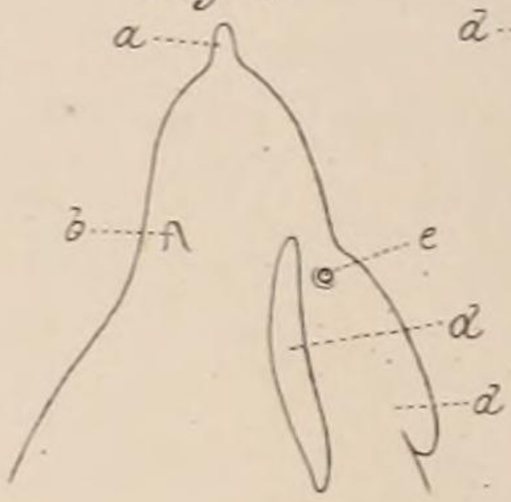
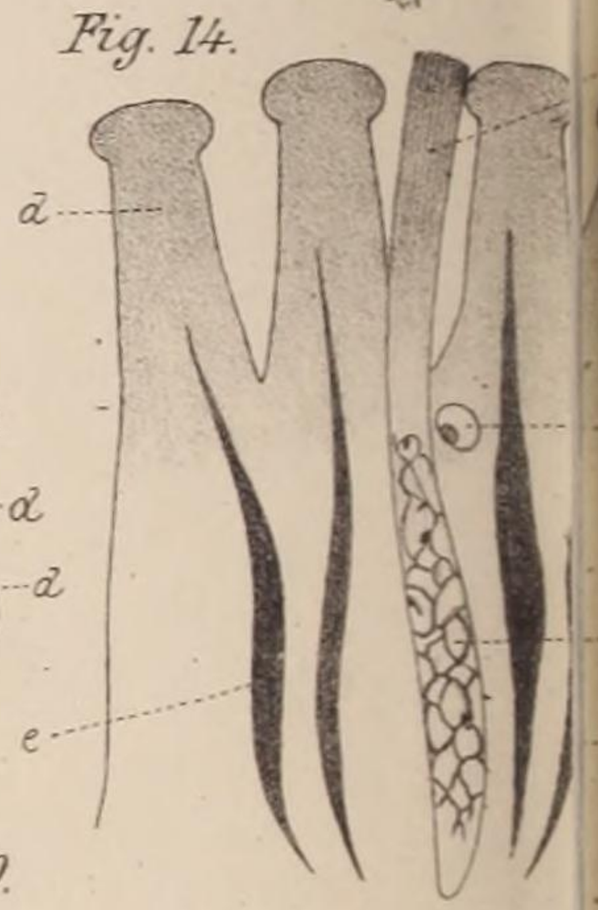


Fig. 7.

Fig. 14.



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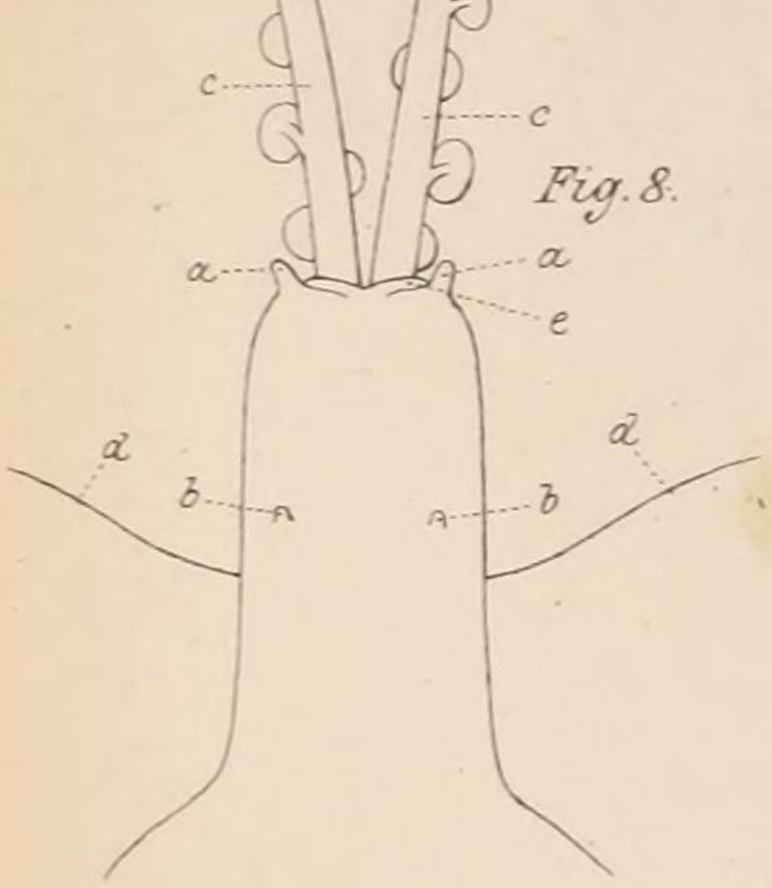

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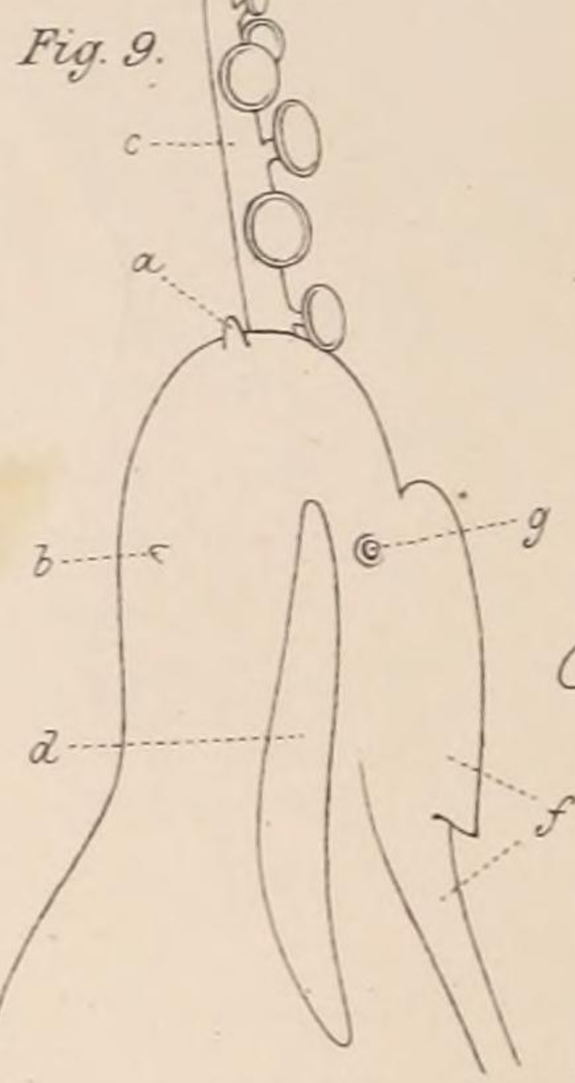

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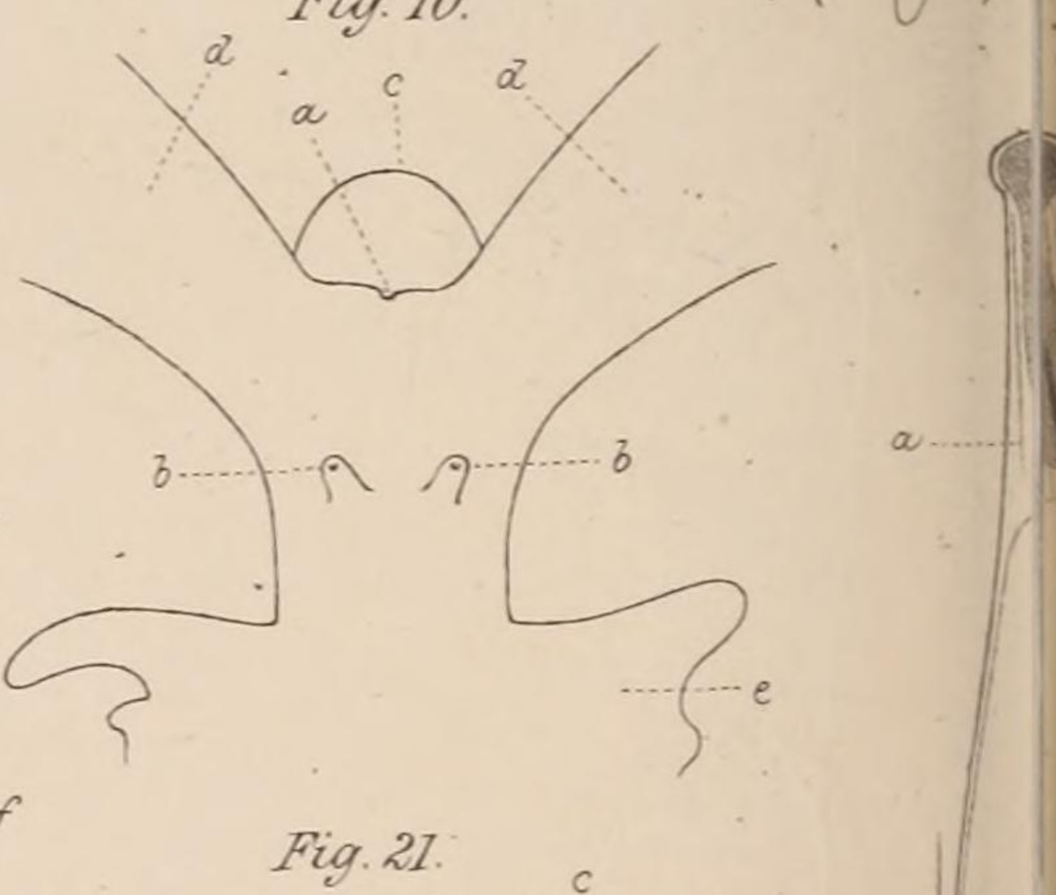

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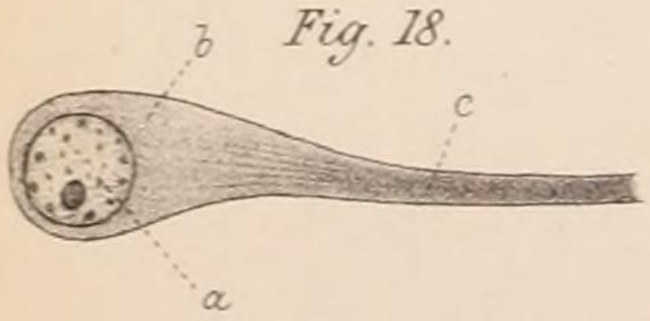

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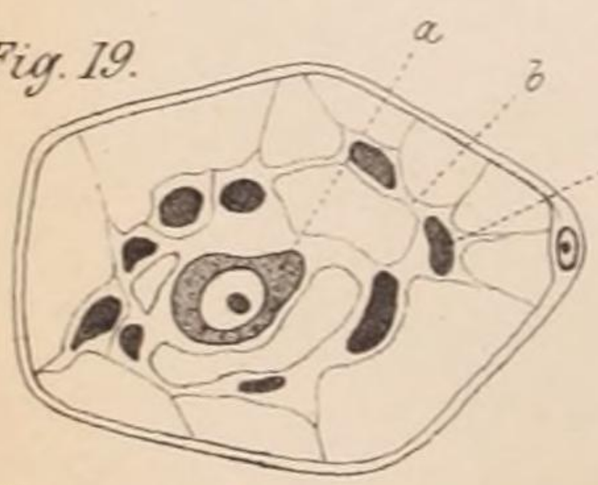

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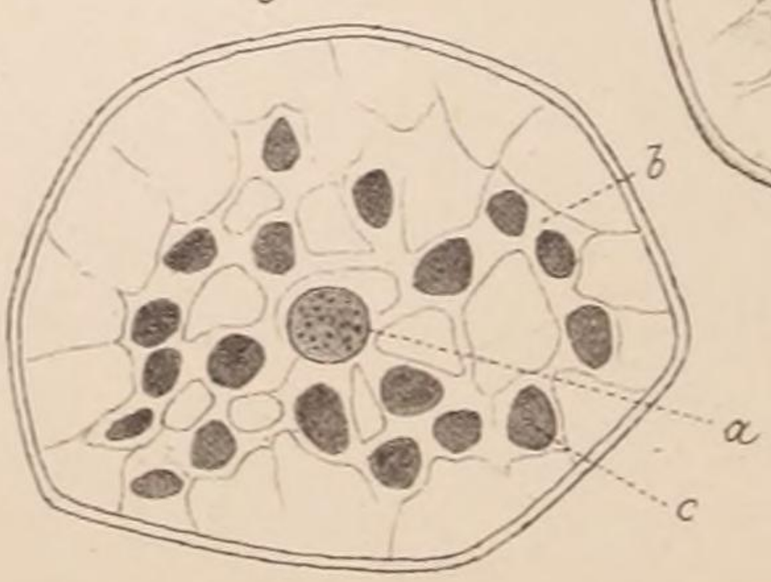

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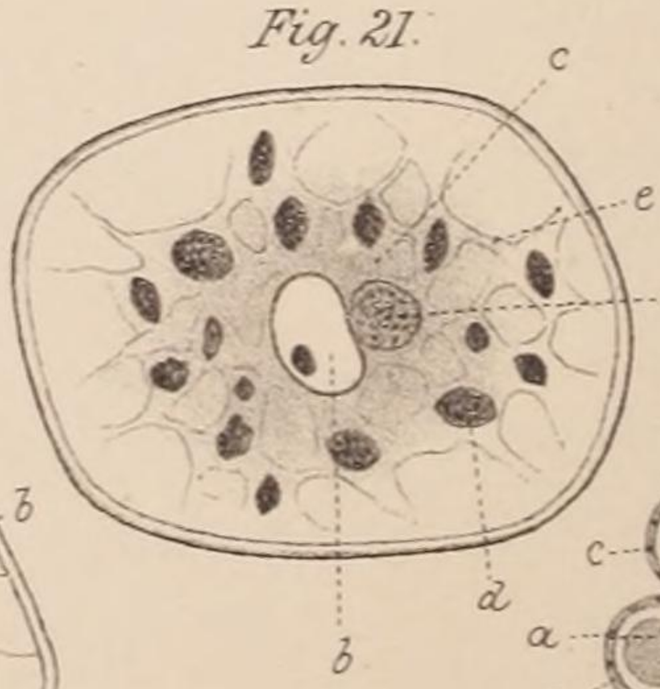

Fig. 22

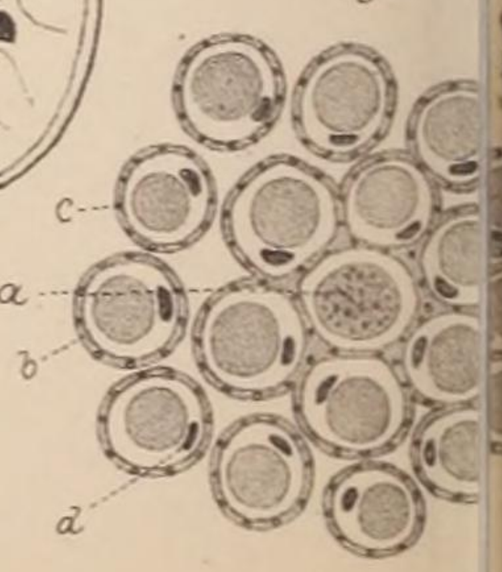

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Fig. 12.

Fig. 13.

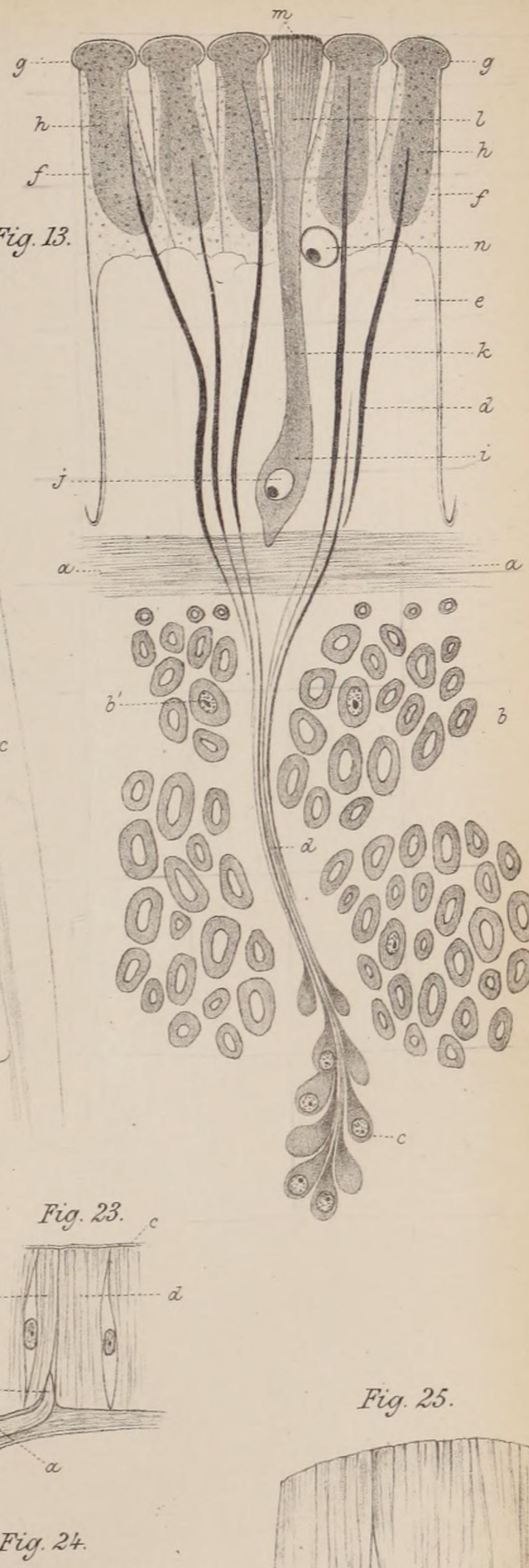


Fig. 16.

Fig. 15.

Fig. 17.

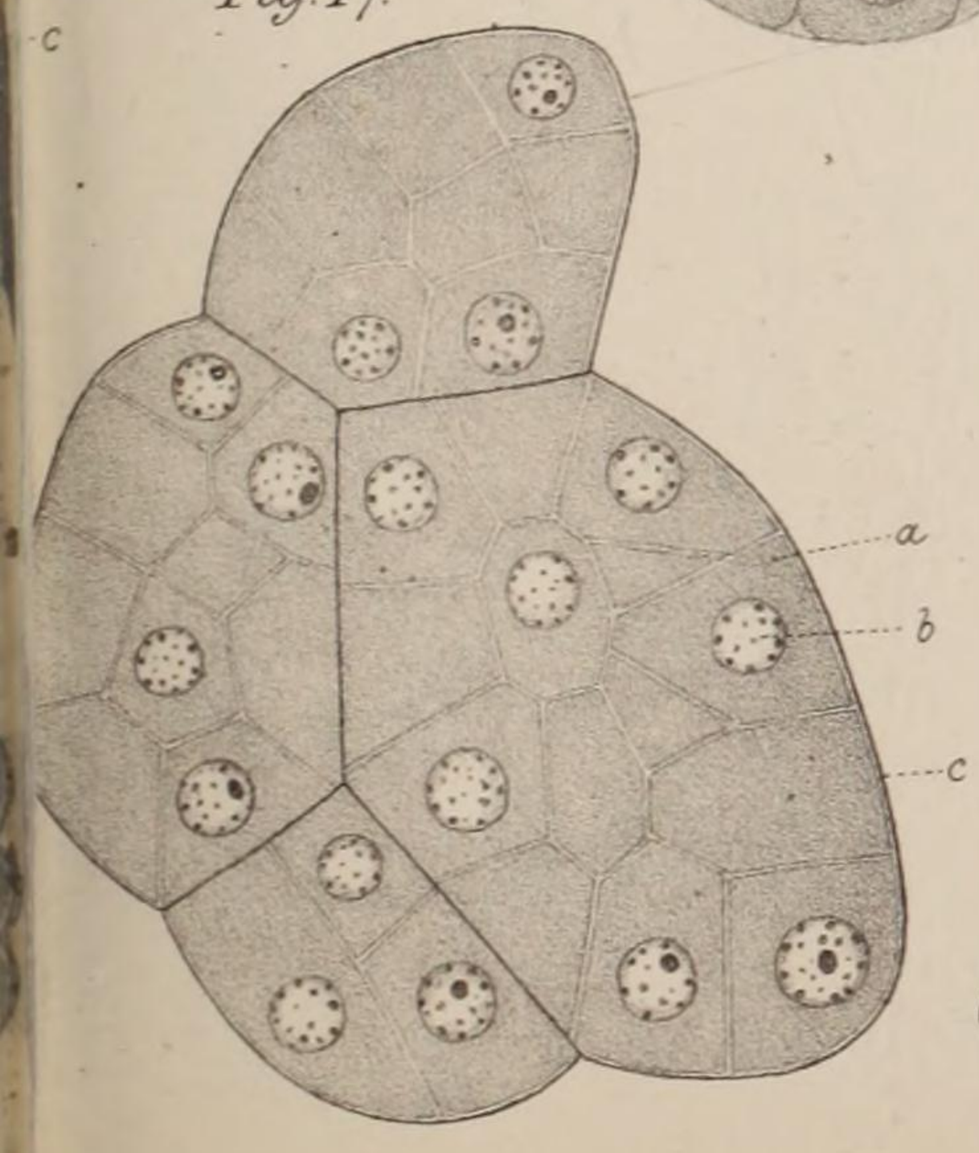
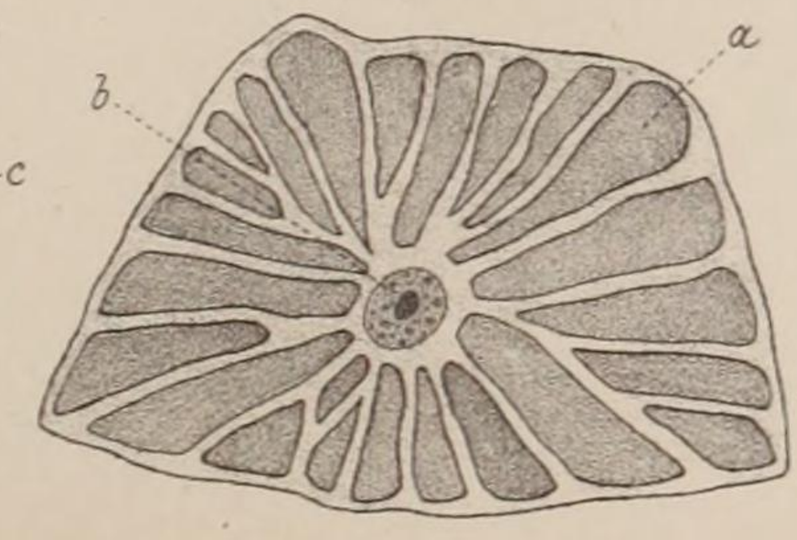


Fig. 23.

Fig. 24.



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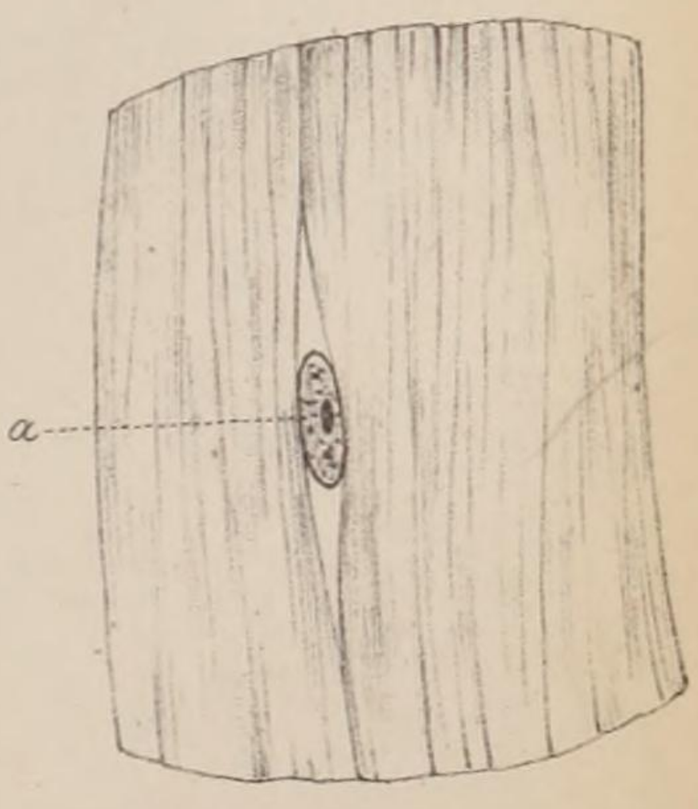

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Fig. 22. Ditto, through the body of the epithelial cells. *a*. Rod or prolongation of the sensorial cell. *b*. Membrane of the epithelial cells. *c*. Striæ of this membrane. *d*. Fibroid secretion.

Figs. 23—25.—Pneumodermon.

Fig. 23. Part of a transverse section of a sucker, showing how the longitudinal muscles of the peduncle are inserted on the muscular disc. *a*. Longitudinal muscular fibre of the peduncle. *b*. Its pointed extremity. *c*. Epithelium of the upper face of the sucker. *d*. Prismatic cells of the muscular disc.

Fig. 24. Transverse section of a prismatic muscular cell. *a*. Prism of muscular fibres. *b*. Nucleus.

Fig. 25. Longitudinal section of a prismatic muscular cell. *a*. Nucleus.