MEDDELELSE FRA DEN BIOLOGISKE STATION NR. 12

ANATOMICAL STUDIES ON ANELASMA AND SCALPELLUM

(WITH 5 PLATES AND 5 FIGURES IN THE TEXT)

BY

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DET KGL. NORSKE VIDENSKABERS SELSKABS SKRIFTER 1918. Nr. 1

AKTIETRYKKERIET I TRONDHJEM
1919

Among the cirripedia inhabiting the Trondhjemfjord, probably the most interesting is *Anelasma squalicola* (LOVÉN) DARWIN. The first description of the species is found in a paper on *Etmopterus spinax* (LINNÉ) by the great Norwegian naturalist, bishop J. E. GUNNERUS (1763). At the base of one of the dorsal fins of some of his specimens of this selachian, he observed a parasite which he describes and figures, so that we easily recognise the characteristic features of the species. GUNNERUS correctly acknowledges the crustacean nature of the parasite, but does not give the species any name, and his description soon passed into oblivion owing to the humble and little-known journal, in which his paper was published. Thus it came about that LOVÉN, who almost a century later (1845) described the parasite in question anew, and gave it the name *Alepas squalicola,* has been generally mentioned as the discoverer of the species. LOVÉN demonstrated that the species is a cirriped. His description was rather cursory, and CHARLES DARWIN therefore supplemented it in his meritorious, great monograph on recent cirripedia (1851). His details are given partly after dissection of a specimen sent him by the Danish zoologist JAPETUS STEENSTRUP, partly after information in a letter from the latter. The state of preservation of his specimen was, however, far from satisfactory, and many anatomical questions consequently remained open to later investigations. DARWIN created a new genus for the species, viz. *Anelasma.* Later on, GRUVEL (1905) considers *Anelasma* as the type of a subfamily Anelasminae, which besides *Anelasma* also comprises the genera *Gymnolepas,* and *Chaetolepas;* he gives, however, no further contributions to our knowledge of the anatomy of *Anelasma squalicola.*

Some new anatomical details have in the meantime been given by KOSSMANN (1874), and later by GEOFFROY SMITH (1906). DARWIN found no transversal striation in the muscle fibres of *Anelasma,* and judged this as a primitive feature; KOSSMANN, however, demonstrates the transversal striation of the muscles, and thus shows us that the species in this respect joins the remaining cirripeds. He further points out that the species in many respects seems to form a link between the cirripedia pedunculata and parasitica. GEOFFROY SMITH gives some details concerning the structure of the filiform offshoots of the peduncle, and of the

mantle, and believes to have found degenerating ova at the upper side of the ovaries, and in the basal parts of the mantle.

It was thus obvious that also at present anatomical questions concerning *Anelasma squalicola* had to be answered, if we wish to settle its position among the other cirripeds. At my request, Dr. O. NORDGAARD, the director of the biological station at Trondhjem, procured material of the species, and I wish here to express my sincere thanks for his valuable assistance. When we consider that at most seven per cent of the *Etmopterus*-specimens of the fjord are infested with the parasite, it is easily understood that I never should have succeeded in a short time in getting so large a quantity of material as needed, had I not been aided by the biological station.

The investigations soon revealed the impossibility of settling many questions from the litterature alone, without comparison with other p e d u n c u l a t a. During our fjord investigations I had ample opportunity of obtaining material of *Scalpellum Strømii* M. SARS, and my investigations have then naturally been extended to a comparative study of *Anelasma* and *Scalpellum*. Owing to the very scanty material of developing stages and small specimens of *Anelasma* I have at present confined myself to a study of the adult ones, and, moreover, chiefly laid stress on elucidating the alimentary organs and the cementary glands, which latter were hitherto unknown in *Anelasma*.

The study of histological details requires other methods of fixation than those commonly used on expeditions where material is gathered for systematical and geographical purposes. Even though a fixation in formaline may suffice for many purposes also in anatomical respects, it is soon found that in studies such as the present, it is necessary to have recourse to other fixing solutions. The best results I have obtained with BOUIN's solution (3 parts concentrated hydrous picric acid, 1 part formaline + 3—5 % acetic acid), and with RABL's solution (equal parts of concentrated hydrous solutions of picric acid, and sublimate + 2—5 % acetic acid).

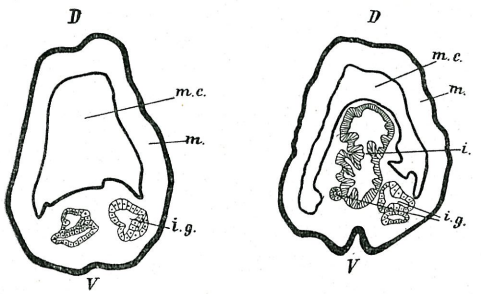
The microtome sections have been stained in different ways. Good results for general purpose were obtained with DELAFIELD'S haematoxyline — van GIESSON. For finer details, the following staining methods were especially useful: WEIGERT'S haematoxyline — iron ammonium sulfate, BØHMER'S haematoxyline — eosine, and boraxcarmine — bleu de Lyon. A special interest is attached to the latter double staining; bleu de Lyon shows special affinity to the chitinogene parts, which attain a clear blue colour, and thus serves to distinguish the chitinogene cuticle of the stomodæum and proctodæum from the covering layer of the digestive intestine.

Anelasma squalicola (LOVÉN) DARWIN.

The coarser anatomy of *Anelasma* has been exellently demonstrated by DARWIN (1851 p. 170), and I shall here restrict myself to som topographic remarks which are of general interest in connection with the histological details.

The parasites are generally found at the base of the dorsal or anal fins of *Etmopterus spinax*. The parasite is very seldom single; in most cases we find two specimens at the base of one fin, but in some cases I have more specimens, in one case even five in one cluster. In a letter to DARWIN, JAP. STEENSTRUP mentions that there are always two individuals sitting together; this remark, in connection with the hermaphroditic nature of the animals, caused GRUVEL (1905) to suppose that a cross fertilisation would probably be found on closer investigation. I have not succeeded in observing the act of fertilisation, and shall not discuss GRUVEL's supposition here; it has only to be remembered in this connection that the ovaries and the testes in the individuals investigated ripen at the same time in one animal.

Embedded in the body of the shark we find the well developed peduncle which is provided with rootlike filaments or offshoots. LOVÉN (1845), and as far as may be judged, also DARWIN, merely considered these filaments as organs of adhesion, serving to keep the animal fixed in the shark's body. KOSSMANN (1874) on the other hand, maintains that the filaments are also nutritive organs, and provide the parasite with most of its food at the cost of its host. Also GEOFFROY SMITH (1906) seems to share this supposition after a comparison of the filaments with similar organs of the Rhizocephala.



Textfig. I. Transverse sections of a small *Anelasma squalicola*, the free part of which projects 1,5 mm above the sharks skin. a section through the «stalk», b section through the thorax in the lower part of the proboscis. [× 15]. D = Dorsal side; V = ventral side; m. = mantle; m. c. = mantle cavity; i. = digestive intestine; i. g. = digestive gland.

The large peduncle of *Anelasma* contains the enormous ovaries which occupy most of its interior. At the upper side of the ovaries, and in the basal parts of the mantle, GEOFFROY SMITH believes to have observed degenerating ova in large numbers; as I have demonstrated in a preliminary report (1918), these «degenerating ova» are in fact the cementary glands of *Anelasma* which have escaped the attention of previous investigators, partly owing to the bad state of preservation in the animals investigated. — From the ovaries the paired oviducts pass through the basal part of the thorax, and end into the paired atrium which opens at the base of the first pair of cirri.

The mantle of *Anelasma* (pl. I, fig. 1) is comparatively large, and distinguished by the complete lack of calcareous formations. Certainly, LOVÉN states that he has observed minute dendritic calcareous particles in the mantle, and even gives a figure of them; DARWIN however, could not confirm LOVÉNS observations, and neither KOSSMANN nor GEOFFROY SMITH make any allusions to these formations; I have in vain sought for such calcareous formations even in fresh material. — DARWIN assumes that the proboscis of the animal cannot be covered by the mantle; this supposition does not hold good, many of the specimens investigated in a living state being wholly wrapped up in their mantles.

The thorax of *Anelasma* (pl. I, fig. 2) is characterised by its reduced cirri and its rather short and stout penis. The oral part of the thorax is transformed into a prominent proboscis furnished with remarkably reduced mouth feet.

The internal anatomy has hitherto only been little studied. In the alimentary canal we may distinguish four regions, viz. the oesophagus, the stomach, the digestive intestine, and the proctodæum. From the mouth opening (pl. I, fig. 2) a rather short oesophagus leads in dorsal direction to the stomach; it is endowed with a well developed musculature. The small, but richly folded stomachal part, which is almost destitute of musculature, opens into the digestive intestine, which is very voluminous, and furnished with a great lumen; the digestive intestine occupies almost the dorsal half of the thorax, and runs parallel with the dorsal side of the animal, making a rounded bend in its foremost part. Through a sharp restriction it is distinguished from the proctodæum, which is rather narrow, and terminates in the anus situated at the dorsal and basal side of the penis; there is a short furrow at the dorsal side of the penis behind the anus proper. On each side of the digestive intestine, and in the basal part of the thorax (the «stalk») a large, branched digestive gland is situated; it opens through a short duct into the digestive intestine shortly behind the stomach, one duct on either side of the intestine. — The ventral part of the

thorax is occupied by the large testes; these are shaped like two clusters of grapes, and lie tightly packed together, one on each side of the sagittal plane.

Textfig. II. Transverse sections of the thorax of a fullgrown *Anelasma squalicola*. a at the lower side of the proboscis (the mantle is omitted), b on the level with the atrii, c just below the base of the penis. The muscles red. [× 10]. D = dorsal, V = ventral side of the animal. A = atrium; i. = digestive intestine; i. g. = digestive glands; p. = proctodæum; m. c. = mantle cavity; od. oviduct; T. = testes.

A study of the histological structures shows us that the oesophagus is lined by a rather thick cuticle (pl. I, fig. 3—4), the direct continuation of the thoracic cuticle; it shows a pronounced affinity to bleu de Lyon. The cuticle is supported by a cylindric epithelium consisting of small and narrow, but rather high cells; the cells are, especially nearer the mouth opening, richly furnished with grains of blackish pigment in their basal part. In the hinder region of the oesophagus the pigment decreases little by little, and disappears wholly near the transition to the stomach. The muscles of the oesophagus are extremely powerful and, especially nearer the mouth opening, remarkably concentrated, the fibres almost everywhere lying closely packed together. It is therefore in most places impossible to detect undifferentiated sarc, and only between fibres of the dilatatory muscles do small portions of undifferentiated sarc seem to occur a little outside of the oesophagal epithelium, where the fibres have not yet gathered into clearly circumscribed muscle bands. In this respect *Anelasma* evidently occupies a higher stage of development in comparison with *Scalpellum* as described farther below. Dilatatory muscles are connected with the cuticle by fine threads running between the epithelial cells (pl. I, fig. 4); these threads exhibit a pronounced affinity to acid fuchsine, and thus strongly contrast with the muscle tissues proper, which after treatment with van GIESSON'S staining method attain a vivid yellow colour, owing to the picric acid. On the other hand, the connective threads in question, from their indifference to bleu de Lyon, contrast with the cuticula. The dilatatory or radial muscles gather into strong muscular bands, connecting the oesophagal wall with the external cuticle of the proboscis. Round the oesophagus indistinctly circumscribed ring muscles form an almost continuous sheath; this is extraordinally powerful nearer the mouth opening, but decreases backwards, and almost disappears at the transition to the stomach.

The stomach proper is richly furnished with deep longitudinal folds, and covered by a rather delicate cuticle, the direct continuation of the oesophagal cuticle. The cuticle of the stomach is in *Anelasma* rather thick in comparison with that of *Scalpellum*, and the transition to the cuticle-like lining of the intestinal epithelium is somewhat abrupt (pl. I, fig. 5). The epithelium of the stomach consists of high and narrow cells, and contrasts rather markedly with that of the digestive intestine; on the other hand it differs only slightly, if at all, from the oesophagal epithelium. The stomachal epithelium is destitute of pigment. In comparison with *Scalpellum*, the stomach proper of *Anelasma* is very indistinctly bounded against the oesophagus, indeed no definite boundary can be pointed out; the denomination of stomach is here

used in analogy with other cases among the cirripeds, as a designation of the exceptionally richly folded, and consequently a little swollen connecting part, where the cuticle of the oesophagal part yet lines the epithelium, and where, on the other hand, the muscles have faded away or are at all events only very feebly developed. In reality the stomach of *Anelasma* can only be made out on account of its deeply folded walls, which (pl. I, fig. 2 s.) give it a somewhat swollen appearance; it is yet furnished with muscles, although these muscles are only feebly developed in comparison with the oesophagus proper, and especially the dilatatory muscles. The boundary between the stomach and the digestive intestine is on the other hand very distinct (pl. I, fig. 5), the cuticle of both regions being principally different.

The d i g e s t i v e i n t e s t i n e is covered by a cylindric epithelium with distinct basal membrane (pl. I, fig. 6, pl. V, fig. 22). Each epithelial cell is furnished with a finely striped distal zone; the boundaries between the cells are generally invisible in these distal parts, and the striped zone mentioned therefore seems to form a continuous layer or cuticle on the surface of the epithelium. In its affinity to staining substances this cuticle differs strikingly from the cuticle of the stomach, oesophagus, and proctodæum, the latter attaining a clear blue colour after staining with boraxcarmine-bleu de Lyon, whereas the intestinal «cuticle», like most protoplasmatic substances, assumes a violet hue; the fine stripes perpendicular to the surface are distinctly seen in all sections of the intestine.

The protoplasm of the intestinal epithelial cells is finely granulated. The nuclei are generally situated in the middle of the cells; they are provided with one, or seldom two nucleoli, but other chromatic substances seem to fail almost completely. In other words, the intestinal cells convey the impression of resting cells, a fact probably dependant on the constant absence of nutritive particles in the intestines of the individuals investigated. Even in a small specimen, the free part of which had a height of 1,5 mm. above the skin of the shark, the nuclei of the intestine only showed traces of chromatic network beside the nucleoli, a rather interesting feature when taken together with the features of the digestive glands stated below. — The intestine is destitute of muscles.

The p r o c t o d æ u m is distinctly bounded towards the intestine (pl. I, fig. 2). Its very low cylindrical or almost cubical epithelium is richly furnished with blackish grains of pigment in the basal parts of the cells, and moreover covered by a rather thick homogeneous cuticle (pl. II, fig. 7), the direct continuation of the thoracic cuticle. Here as elsewhere the cuticle exhibits a pronounced affinity to bleu de Lyon, attaining a clear blue colour. The muscles of the proctodæum are rather diffuse, and only more richly developed at

the transition from the intestine; we can nevertheless distinguish three main layers of muscle fibres, viz. longitudinally arranged muscles supporting the epithelium, ring muscles outside these, and lastly, radial or dilatatory muscle bands connecting the proctodæal cuticle with the external thoracic cuticle. On the whole, the muscles of the proctodæum are, as mentioned above, only feebly developed, and the proctodæum generally affords the impression of being wide open.

«Salivary glands» could not de traced in *Anelasma*. On the other hand, large digestive glands open into the foremost part of the digestive intestine shortly behind the stomach. There are two digestive glands, one on each side of the sagittal plane. In the small specimen above mentioned, the glands were only slightly branched, and in their outlines rather resemble the digestive glands of *Scalpellum*. The glands of this small *Anelasma* seemed to be in vivid function. (pl. II, fig. 9), and exhibited the structure of «pancreatic» glands according to GRUVEL (1904, 1905). The single cells are of different sizes, probably owing to their state of function. The protoplasm is rather coarsely granulated. In the middle of the cell a large nucleus is situated; after staining with WEIGERT's hæmatoxyline—iron ammonium sulphate, the chromatic network is distinctly visible, although its affinity to the dye is far less than that of the large and irregularly shaped nucleoli; the latter altain a completely black colour. In exceptional cases, many minute nucleoli are found in one nucleus; generally one large nucleolus appears, often accompanied by some small ones.

In fullgrown specimens, the digestive glands present a very different picture. Here the glands are richly branched, showing an intermediate stage between tubular and alveolar construction. It is impossible to designate them as pancreatic, hepatic, or hepatico-pancreatic glands in accordance with the terminology of GRUVEL. Staining after WEIGERT's method (pl. II, fig. 10) shows us a series of cells containing rather large nuclei richly furnished with chromatic substance. Even though now and again large nucleoli may be found, the latter are more frequently hidden by (or dissolved into?) numerous rather coarse, and closely packed granula exhibiting the same intense affinty to the dye. The protoplasm is evenly granulated in the basal part of the cell; in the distal part on the other hand, it is strongly vacuolated, and here almost conveys the impression of degenerating or only feebly functionating cells. This impression is strengthened by the picture presented by sections stained with boraxcarmine — bleu de Lyon (pl. V, fig. 23). Here the protoplasm is but little influenced by the blue dye, and it is strikingly vacuolized, almost attaining a foamy appearance. The nuclei in this case give the picture of nuclei of resting cells,

containing one, or seldom two nucleoli, and seemingly almost destitute of other chromatic substance. Alltogether, we may say that the digestive glands in young specimens convey the impression of being in vivid function, whereas in fullgrown specimens they present distinctly degenerative signs.

The latter phenomenon probably stands in connection with the development of new alimentary organs, namely the offshoots or filaments of the peduncle. These filaments are covered by a homogeneous cuticle, the direct continuation of the cuticle of the peduncle. The cuticle of the filaments is rather thick nearer the peduncle, but decreases little by little towards the distal part of the filament, and at last disappears entirely, so that the tips of the filaments are naked (pl. II, fig. 11 and 12). In their inner anatomy GEOFFROY SMITH (1906) speaks of two cell layers; this, however, is not fully correct. In the proximal part we may speak of two cell layers; here the epidermal epithelium of the peduncle is continued for some distance, supporting the cuticle of the filament; but this cell layer soon disappears. In the distal parts of the filaments (pl. II, fig. 11, 12) only mesodermal tissue is found as a direct continuation of the mesodermal tissue of the interior parts of the peduncle. In young specimens, this tissue forms a lacunary, uniserial epithelium, in fullgrown specimens on the other hand, the tissue becomes multiserial; here the outer cells have their nuclei lying near the external cuticle, and this may on superficial investigation convey the impression of two cell layers in the filament. In the centre of the offshoot, an irregular central canal leads from the distal part into the mesodermal, lacunary tissue of the peduncle, and connects here with the lacunæ of the connective tissues all over the entire animal. Allhough the observations of GEOFFROY SMITH may to some extent be said to be incomplete, his investigations convey the impression that the structure of the filaments in *Anelasma* agrees with that of the Rhizocephala, and this likewise speaks in favour of the supposition that the filaments also in *Anelasma* serve as food absorbing organs. Their influence on the tissues of the host, which is described farther below, support this supposition.

In this connection, the cementary glands must also be mentioned. In free-living barnacles, the ducts of the single gland cells gather into two main canals or ducts, which debouch at the base of the peduncle. In *Anelasma* I have vainly tried to trace such main canals; the small ducts of the cementary gland cells seem to lead out into the lacunes of the connective tissues, and accordingly to empty their secretions into these lacunes.

The cementary gland cells are very numerous, and distributed over the upper part of the peduncle at the upper (hinder) side of

the ovaries, and over the basal parts of the mantle. It is evidently the same cells that have been interpreted by GEOFFROY SMITH (1906) as degenerating ova. The cementary gland cells are very large (pl. III, fig. 13—15); their protoplasm is finely granulated. The nuclei are very large; in most cases the nuclei are amoeboid or branched in the gland cells of fullgrown individuals; they are richly furnished with chromatic substance, which after treatment with WEIGERT'S haematoxyline—iron ammonium sulphate seems to form an almost compact mass of amoeboid shape. In young individuals (pl. III fig. 13) the nuclei have a more regular shape and structure, and may here in this respect somewhat resemble unripe ova. In the small specimen previously referred to there is a large distance between the zone of the cementary glands, and the ovary; the latter as yet only consists of a small number of closely packed ovogonia, and the circumstances here evidently refute GEOFFROY SMITH'S supposition of the cementary gland cells as degenerating ova in *Anelasma*. — In fullgrown specimens, the nuclei are indistinctly circumscribed, and generally adjoin one or more great vacuoles in the protoplasm (pd. III, fig. 15), the vacuoles attaining different shape and size, and being very indistinctly bounded.

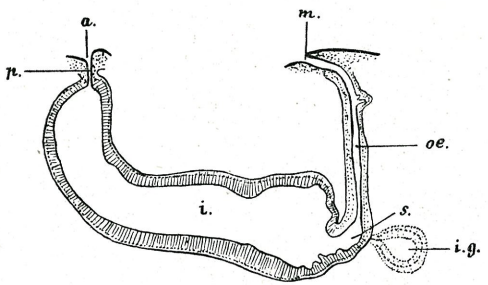
Staining with boraxcarmine—bleu de Lyon gives an interesting picture (pl. V, fig. 24). The nuclei are seen to be rather richly furnished with granular chromatic substance in the shape of smaller or larger nucleoli, some of them being even of quite considerable size; on the other hand, the chromatic substanse here is not nearly so compactly constructed as in preparations stained with WEIGERT'S haematoxyline—iron ammonium sulphate. Also in the sections stained in boraxcarmine, the boundaries of the nucleus are mostly very indistinct. It is obvious that the protoplasm of the gland cells in *Anelasma* is almost indifferent towards bleu de Lyon; as on the other hand, it has a remarkable affinity to boraxcarmine, the protoplasm of the cementary gland cells in this case is rather red, and thus contrasts sharply with the violet tissues remaining. The cementary gland cells of *Anelasma* differ strikingly in this respect from those of *Scalpellum*, where the protoplasm attains a blueish violet hue owing to its affinity to bleu de Lyon In *Anelasma*, the protoplasm of the gland cells and that of the cells of the duct also clearly differ, owing to their different affinity to the bleu de Lyon.

From each of the great cementary gland cells one or two ducts take their departure (pl. III, fig. 15). The wall of the duct consists of a single-rowed cubical epithelium, and the gland cell surrounds the initial part of the duct like a cap. Only in rare cases do the ducts of two neighbouring gland cells communicate; the ducts

generally seem to be short, and debouch into the lacunes of the surrounding connective tissues as previously mentioned. I shall in the last section, dealing with the general results, return to the probable part which the cementary glands play in the life history of *Anelasma*.

Scalpellum Strømii M. Sars.

This species occurs in great numbers on the larger Hydroid colonies in the Trondhjemfjord, where it must be characterised as the commonest species of the pedunculate cirripeds. I have in a previous paper (1912) described the development of its calcareous plates, giving the general features of its occurence in the fjord. — *Scalpellum Strømii* is highly organised, and feeds especially upon smaller crustaceans; this is easily demonstrated by the microtomic sections, and I have never studied a fullgrown specimen without finding remains of small crustaceans in the digestive intestine.

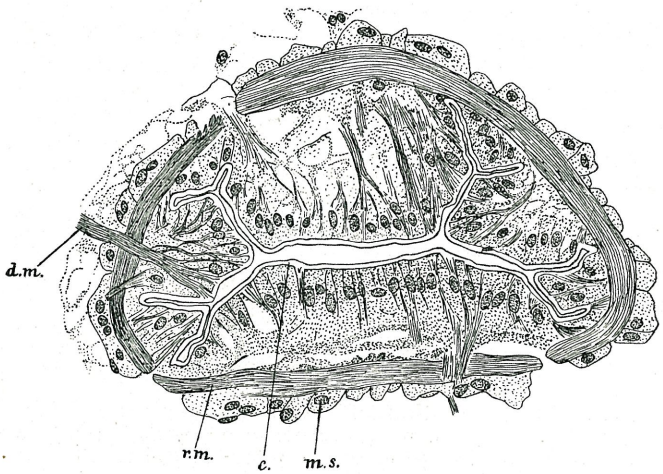


Textfig. III. Sagittal section of the alimentary canal of *Scalpellum Strømii* [× 20] m. = mouth opening; oe. = oesophagus; s. = stomach; i. g. = digestive gland (lying below the plane of the rest of the figure); i. = digestive intestine; p. = proctodæum; a. = anus.

The general features of the anatomy are as follows. The peduncle in its upper part contains the ovaries, and beside these, at their upper (hinder) side one pair of compound cementary glands. The cementary glands never enter into the mantle. — In the thorax, the oral part is not very prominent; on the other hand, it is armed with highly developed, powerful mouth feet. The mouth opening leads into a rather long oesophagus (textfig. III) which almost occupies one third of the entire alimentary canal. The stomach is small and very little distinct; through a rather abrupt widening it opens into the digestive intestine, which has a wide lumen, and is almost perpendicular to the oesophagus. The proctodæum is very short, and narrow, and marked off from the digestive intestine by an abrupt narrowing. Just behind the transition from the stomach, one pair of digestive glands opens into the digestive

intestine through two narrow openings or short ducts; the glands have an almost globular shape, and show no indication of branching or division.

The oesophagus (textfig. IV) is lined with a rather thick, homogeneous, and chitinogene cuticle, the direct continuation of the external thoracic cuticle; the oesophagal cuticle accordingly exhibits an intense affinity to bleu de Lyon (pl. V, fig. 25). The cuticle is supported by a cylindric epithelium with not very high, and indistinctly circumscribed cells. Radial dilatatory muscles are connected with the oesophagal cuticle by fine fibres inserted between the epithelial cells; the dilatatory muscles form strong muscle bands, and have their other end fixed to the external



Textfig. IV. Transverse section of the oesophagus in *Scalpellum Strømii* [× 200]. c. = cuticle; d. m. = dilatatory muscle; r. m. = ring muscle; m. s. = undifferentiated sarc of the cells of the ring muscle.

thoracic cuticle. Outside the epithelium, strong parallel ring muscles build a sheath round the oesophagus; the ring muscles almost seem to be stronger than the dilatatory muscles; they consist of epithelial muscle elements with large bodies of undifferentiated sarc fixed to the external side of the muscle sheath (pl. V, fig. 25, textfig. IV, ms.). In longitudinal sections of the oesophagus (pl. IV, fig. 17) we observe how the distal part of the dilatatory muscles, or better the connective part between the oesophagal cuticle and the dilatatory muscle proper, exhibits a more sinew-like structure; the connective parts seem to be arranged in indistinct longitudinal rows, and are themselves connected by cross-connections inside the sheath of ring muscles. As mentioned,

these connective parts exhibit an almost sinew-like appearance; with the aid of VAN GIESSON's staining method the principal difference between the muscle proper and the connective part can be distinctly demonstrated, the latter being coloured a vivid red, owing to its affinity to acid fuchsine, whereas the muscle proper is stained an intense yellow by the picric acid. The staining of the connective parts thus in this case coincides with that of the cuticle. There is nevertheless also a principal difference between the cuticle and the connective parts, as is demonstrated by preparations stained with boraxcarmine-bleu de Lyon; in this case the cuticle is bright blue (pl. V, fig. 25), whereas the connective parts between the muscles and the cuticle attain the same faint violet colour as the protoplasm of the oesophagal epithelium. The transverse stripes of the muscle fibres are, of course, lacking in the connective parts. — In the longitudinal sections the ring muscle sheath is seen to consist of individual bundles of muscle fibres (pl. IV, fig. 17, rm.) with undifferentiated bodies of cytoplasm containing the large nuclei; the undifferentiated sarc is fixed to the muscle at the side turning away from the lumen of the oesophagus.

In connection with the oesophagus we may also mention the socalled »salivary glands» («glandes salivaires» of GRUVEL 1905, «Undefinierbare Organe 2», NUSSBAUM 1890) even though they are situated outside the alimentary canal proper, and in *Scalpellum Strømii* show no direct connection with the latter. The glands in question are in this species gathered in two large groups, one group at the oral side of the basis of each of the first pair of cirri. In transverse sections through the basis and the basal joint of the cirrus, the glands are gathered in the ventro-lateral parts, and comprise one half to two thirds of the section of the basal joint, and in longitudinal sections of the latter about one half of its length. The secretions are emptied directly through minute pores in the cuticle, without formation of special ducts.

The entire organ is composed of large gland cells (pl. IV, fig. 19; pl. V, fig. 28); the nuclei are large, and situated in the middle or basal part of the cell. The nucleus contains a large nucleolus; the latter, after fixation in BOUIN's fluid, is intensely blackened by WEIGERT's haematoxyline—iron ammonium sulphate, it is also rather distinctly visible when treated with boraxcarmine, whereas DELAFIELD's haematoxyline, on the other hand, does not stain it at all. The staining methods mentioned further demonstrate that the other chromatic substance of the nuclei occurs as a great many smaller, intensely colouring granulations. When the animal has been fixed in formaline, a staining in WEIGERT's haematoxyline—iron ammonium sulphate only demonstrates the nucleolus, the chromatic granula mentioned above remaining uncoloured. In

this case the cytoplasm always showed a coarsely vacuolated structure; after fixation in BOUIN's fluid on the other hand, the cytoplasm appears to contain a great many secretion drops, which are intensely blackened on staining after WEIGERT's method; also DELAFIELD's haematoxyline shows some affinity to the secretorial drops. The secretions also exhibit a rather intense affinity to eosine, and after treatment with VAN GIESSON's staining method are coloured an intense yellow by the picric acid. An interesting picture is offered by sections stained with boraxcarmine-bleu de Lyon (pl. V, fig. 28). The basal parts of the cells below the nuclei are to some degree stained by both dyes, and thus attain a light violet hue; the bleu de Lyon on the other hand, does not stain the cytoplasm of the outer parts, and here only gives the secretorial drops a violet hue.

As a result of the staining experiments we find that the cells are typical serocytes, or albumen cells; no trace of mucin was to be found. In connection with the varying position of the glands in question in different genera of the pedunculate cirripeds, this throws a doubtful light on the suggestion of GRUVEL that we have here salivary glands; salivary glands moreover ought to communicate directly with the alimentary canal. — If we bear in mind that *Scalpellum Strømii* at all events mainly preys upon smaller crustaceans, the size of which is often rather large in comparison with the cirriped itself, it would seem natural to suppose that the glands in question may be poison glands, serving to paralyse the animal captured. This supposition also seems to concur better with the nature of the gland cells as pure serocytes. A further objection to the theory of the glands as salivary glands is their remote position in relation to the mouth or the alimentary canal. On the other hand their situation beneath the mouth opening, where the prey after all probability is killed, decidedly speaks in favour of their having a poisonous function. —

At the transition from the oesophagus to the digestive intestine, a small region of the alimentary canal must be judged as the stomach. This rather short part of the alimentary canal differs from the oesophagus proper by its complete lack of muscles. The cuticle of the stomach is a direct continuation of the oesophagal cuticle, and covers the entire surface of the stomach. It is supported by a cubical epithelium; the boundaries between the cells are generally very difficult to trace, and the epithelium accordingly in many cases conveys the impression of a syncytium. At the transition to the digestive intestine (pl. IV, fig. 18) the cuticle becomes thinner, and disappears at last completely. The transition from the stomach to the digestive intestine is generally distinctly emphasized by a sharp constriction of the alimentary canal; this constriction

may nevertheless fail in some specimens. At the transition to the digestive intestine, the alimentary canal makes a sharp bend; the ventral wall, i. e. that situated next to the cirri, forms as a rule a right angle, whereas the opposite, dorsal wall shows a more equal bend throughout the entire stomachal region.

The digestive intestine is covered by a cylindrical epithelium consisting of high cells. All the specimens investigated had their intestine filled up by food, and the digestive cells showed a vacuolised structure when stained with DELAFIELD — VAN GIESSON (pl. IV, fig. 18). Staining with boraxcarmine-bleu de Lyon gives another picture (pl. V, fig. 26) showing an almost evenly granulated protoplasm. The cells are lined with a cuticle exhibiting a finely transversely striped structure («Stäbchensaum»). The nuclei of the cells are rather large. It will be of interest here where dealing with the nuclei of vividly functioning cells to mention their relation to different staining fluids. Treatment with DELAFIELDS, haematoxyline demonstrates a great many chromatic granulations in the nuclei (pl. IV, fig. 18); these granulations are also strongly coloured in boraxcarmine (pl. V, fig. 26). If, on the other hand, we make use of WEIGERT's haematoxyline—iron ammonium sulphate, the nuclei only seem to contain one, or seldom two black-coloured, rather small nucleoli. Excepting the glandular cells, which will be treated farther below, the last picture is typical for all somatic nuclei throughout the body of *Scalpellum*, and this seems, moreover, to be the general result of the staining method mentioned throughout the cirripeds, as previously indicated under the heading of *Anelasma*.

The digestive intestine also in *Scalpellum* lacks muscles. The epithelium is furnished with a strongly prominent and rather thick basal membrane (pl. V, fig. 26); herein it also differs from the stomach, where the basal membrane is only feebly developed, and from the oesophagus, where a basal membrane of the epithelium is completely wanting.

Through an abrupt constriction, the digestive intestine passes into the short proctodæum; this last part of the alimentary canal is richly provided with longitudinal folds of varying prominence. The epithelium is rather low, almost cubical, and the boundaries of the single cells are extremely difficult to demonstrate; the proctodæal epithelium forms the direct continuation of the thoracic epithelium, and is, like this, lined with a homogeneous, structureless and chitinogene cuticle displaying a strong affinity to bleu de Lyon. The cuticle of the proctodæum is a little thinner than the external thoracic cuticle. In its broad features, the proctodæum is built like the oesophagus; the ring muscles, however, are in the proctodæum coalesced to some degree, forming an almost con-

tinuous sheath, and not displaying a series of parallel rings or belts as in the oesophagus. — The proctodæal muscle fibres, like all muscle fibres of *Scalpellum*, are distinctly transversally striped.

In the foremost part of the digestive intestine one pair of digestive glands opens into the alimentary canal through two short and narrow ducts, one on each side of the intestine. The gland (textfig. III, i. g.) is almost ball-shaped in outline; the wall consists of high cylindrical cells furnished with a pronounced basal membrane (pl. V, fig. 27) A double staining with DELAFIELD's haematoxyline—eosine sometimes shows that the distal parts of the gland cells are strongly eosinophile, exhibiting less affinity to the haematoxyline ; nevertheless, in general, the protoplasm seems to exhibit a rather pronounced affinity both to the haematoxyline, and to the eosine. The nuclei are large; now they are more basally situated, now to be found more in the middle of the cell, and exceptionally they may even occur in the distal part of the cell. The nuclei contain a strongly developed chromatic network, which exhibits a pronounced affinity to DELAFIELD's haematoxyline (pl. IV, fig. 20) attaining an almost blackish blue colour; they are bladder-shaped, and contain a large nucleolus, which, however, shows a less pronounced affinity to the haematoxyline than the other chromatic components of the nucleus, and which on the other hand is strongly eosinophile, so that in doubly stained preparations it attains a dark violet hue. — A treatment with WEIGERT's haematoxyline—iron ammonium sulphate gives quite another picture (pl. IV, fig. 21); the network, or better the granules of chromatine, are less intensely coloured, whereas the nucleolus is wholly blackened; the cells in this case lose most of their affinity to eosine.

The digestive glands of *Scalpellum Strømii* display a strongly pronounced secretorial function. The double staining with DELAFIELD's haematoxyline—eosine serves best to give the picture of the cells emptied of their secretions, and thus with cytoplasm of alveolar structure (pl. IV, fig. 20); the treament with WEIGERT's haematoxyline—iron ammonium sulphate gives the finest demonstration of the rather filamentary structure of the protoplasm of the cells in function (pl. IV, fig. 21), the secretions, which are only slightly stained, gather in the distal part of the cells. The filamentary structure of the protoplasm is also easily seen in preparations stained with boraxcarmine—bleu de Lyon (pl. V, fig. 27). — The entire gland, as above mentioned, is almost ball-shaped, and communicates with the intestine through a short and narrow duct; the latter has a low, cubical epithelium, and opens into the digestive intestine just behind the stomach.

It is difficult to classify the glands in accordance with the hepatic, hepatico-pancreatic, or pancreatic types as defined by GRUVEL

(1904, 1905). They lack brown granulations, and should accordingly rather approach the pancreatic group, but the minute structure of the cells differs generally from the pancreatic cells as described by GRUVEL. Their function is probably a mixed one, and although they do not completely correspond with GRUVÉL's descriptions, they must be ranged among the hepatico-pancreatic group. We are at present incapable of discerning the chemical character of the glands in question, the only safe basis for a classification in the categories named above.

Finally, some details as to the cementary glands of *Scalpellum Strømii* may be given here. The cementary glands are situated at the upper (hinder) side of the ovaries, under the «stalk» or connecting part between the thorax and the peduncle. The glands consist of a series of large gland cells connected by fine ducts like the grapes of a cluster (pl. III, fig. 16); the fine ducts unite into one main duct leading down the peduncle, and opening out at the base of the same. The animal has two such composite glands, one on each side of the sagittal plane; there are accordingly also two symmetrically placed main ducts in the peduncle. — The single gland cell has a finely granulated protoplasm; the granula exhibit a rather strong affinity to DELAFIELD's haematoxyline, and might thus be judged as mucous; staining with mucicarmine nevertheless completely fails. Whereas the granula as mentioned, are basophile, the cytoplasm is otherwise pronouncedly eosinophile. The nuclei are extraordinarily large, and irregularly amoeboid shaped, generally lobed. The chromatic substance appears as numerous, densely crowded small grains, which are characterized by their pronounced affinity to haematoxylines and boraxcarmine; DELAFIELD's haematoxyline stains them blackish blue. The latter dye also brings to light one or two large nucleoli in the nucleus; also in the cementary gland cells the nucleoli are at the same time eosinophile. The nucleoli are also distinct in preparations stained with boraxcarmine.

The cementary gland cells are evidently in vivid function; nevertheless their secretions could not be made out clearly in the ducts. There must be a difference in the nature of the function of the cementary glands in *Scalpellum* and *Anelasma;* this is clearly shown by their different relation to a double staining with boraxcarmine—bleu de Lyon. In *Scalpellum,* the cytoplasm of the cementary gland cells attains a blueish violet hue, whereas the cytoplasm of the same cells in *Anelasma* (pl. V, fig, 24) attains an almost pure red colour and, accordingly, turns out to be more strongly basophile than in *Scalpellum.*

General results.

In the preceding pages, a division of the alimentary canal into four regions is generally adopted, which, however, does not correspond with the four regions as defined by GRUVEL (1905). A comparison, indeed, shows that our interpretation and definition of the stomach is widely different. According to GRUVEL, the stomach means the foremost part of the digestive intestine where the digestive glands open out. According to the definition here adopted, the stomach means the hinder part of the stomodæal region, where the muscles become scarce or disappear, the folding of the wall extraordinarily rich, and the external shape of the region accordingly rather ellipsoidal. The stomach as defined by GRUVEL is here included in the region of the digestive intestine.

In a comparison of the alimentary canals of p e d u n c u l a t e c i r r i p e d s and c r u s t a c e a d e c a p o d a the regions must be parallelised in accordance with the definitions here adopted. In the decapoda, the stomach as well as the oesophagus — i. e. the entire stomodæal part of the alimentary canal — is lined with a homogeneous cuticle, which is the direct continuation of the external thoracic cuticle. The digestive glands, on the other hand, open into the middle part of the alimentary canal, the digestive intestine proper; the latter is characterised by the striped end parts of the epithelial cells («Stäbchensaum»), the striped cuticle. Also in the E u p h a u s i i d s the same division holds good (comp. RAAB 1914); here again the stomach, both in its cardiacal, and pylorical parts, is lined with a continuation of the thoracic cuticle, and also in this group of crustaceans the middle part of the alimentary canal, the digestive intestine, is characterized by its digestive glands, and by its striped cuticle («Stäbchensaum»). In the c i r r i p e d s, the stomach is reduced to a small subregion of the stomodæal part, whereas the digestive intestine, on the other hand, has attained a large size; the latter part is also here characterised by its striped cuticle («Stäbchensaum»), and by its adjacent digestive glands. Even though the digestive intestine in some cirriped species is indistinctly subdivided into two partitions, nothing speaks in favour of defining the foremost partition as stomach, the less so because the digestive glands in other crustaceans open into the digestive intestine proper.

A comparison of the alimentary canal in *Anelasma squalicola* and the remaining c i r r i p e d i a p e d u n c u l a t a does not reveal any quantitative reduction on account of the parasitic life of the first named species. Quite on the contrary, we must admit that especially the digestive intestine is comparatively almost larger than in *Scalpellum*, the organisation of *Scalpellum Strømii* agreeing with that of the other *Scalpellum*-species investigated by HOEK

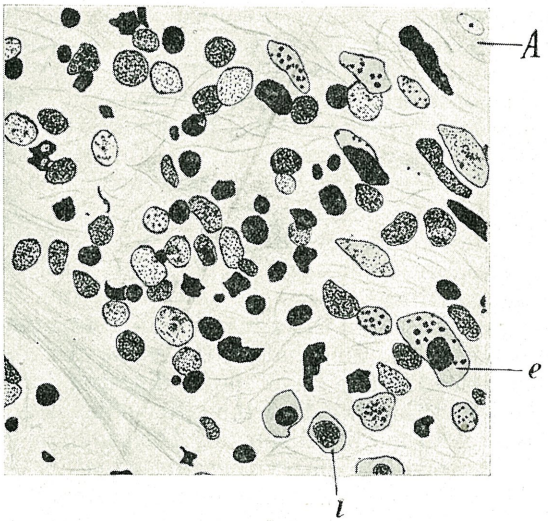
(1883); moreover, the digestive intestine, being richly furnished with tufts and folds, displays a higher development than that of *Scalpellum*. Also the digestive glands with their coarser anatomy, show a far higher organisation in *Anelasma* than in *Scalpellum*. A comparison with *Conchoderma* gives a somewhat different result; according to GRUVEL (1904) the intestinal wall of the latter is no doubt less strongly folded than that of *Anelasma; Conchoderma*, on the other hand, has a great many digestive glands which are, moreover, rather distinctly differentiated into hepatic, hepatico-pancreatic, and pancreatic glands. Nevertheless the differences in the coarser anatomy do not entitle us to speak of the reductive influence of parasitism in *Anelasma*.

Very interesting results are obtained if we take as our starting point for comparison a juvenile specimen instead of an adult *Anelasma*. In the juvenile *Anelasma*, the digestive glands are more simply constructed, and approach those of *Scalpellum;* from their finer structure, they resemble the pancreatic group of glands, and, moreover, display a vivid function. This stands in pronounced opposition to the picture afforded by fullgrown specimens. Although the gland here as a whole is more highly developed, the structure of the single gland cells nevertheless much more implies a strongly reduced function. In this respect we may thus speak of the reductive influence of parasitism. Also the finer structure of the digestive intestine seems to point in the same direction; this may nevertheless also be ascribed to the fact that all the many fullgrown specimens investigated turned out to have empty digestive intestines.

It may be a question, whether the latter point is of importance in our judgment as to the life history of *Anelasma*, or in other words, whether we can take the empty digestive canal as the rule or only as an accident. Probably we have to look on it as the common rule. In this direction the reduced nature of the cirri, and the mouth feet are very important points; the cirri are short and stout, and even in living animals never seem to perform active motions. The mouth feet are excedingly reduced: the palps, and the outer maxillæ, are quite rudimentary and destitute of spines; the inner maxillæ, and the mandibulæ, are very small and feebly armed. Moreover the so-called «salivary glands» of other cirripeds are wanting in *Anelasma*. Even though the oral part of the thorax is developed into a pronounced proboscis, its faculty as a capturing organ must be very small. Taking all this together, we must consider the empty digestive canal as the general rule.

On the other hand, the active function of ovaries and testes in *Anelasma* lays great claim to the provision of food. In *Scalpellum Strømii* I have on extensive investigations found that only about 60 ova develop at a time in the mantle cavity. In comparison with

Anelasma this must be said to be a very small amount, as in the latter species at least about two thousand eggs, large and richly furnished with yolk, are developed at a time in the mantle cavity. There must thus be more need for food in *Anelasma* than in *Scalpellum*. This need must be supplied by other organs than the alimentary canal, and we have here indirect evidence that *Anelasma* absorbs at all events the main supply of its nutriment from its host through the filamentary offshoots which are immersed in the body of the shark. This has already been supposed by Kossmann (1874) and Geoffroy Smith (1906).



Textfig. V. Degenerating tissue of *Etmopterus spinax* at the filament of *Anelasma* (A). e. = degenerating erythrocyte; l. = degenerating leucocyte. [× 460] Rabl. Weigert's haematoxyline—iron ammonium sulfate, van Giesson.

The filaments are, as previously mentioned, in their proximal parts covered by a rather thick cuticle forming the direct continuation of the cuticle of the peduncle. The cuticle is rather thick nearer the offspring of the filament, but becomes thinner the more we approach the distal part of the filament, and at last fades away entirely. The absorbtion of nutriment must accordingly take place at the tips of the filaments. A study of the shark confirms that the filamental end parts of *Anelasma* strongly influence the tissues of the host. Where the filaments of *Anelasma* push on through the muscles of *Etmopterus*, a pronounced degeneration of

the muscle fibres is observed; the muscle tissues degenerate, and are to a great degree replaced by a rich development of connective tissue, which, however, gives a pathologic impression (textfig. V). A closer study at once reveals degenerative features in the tissue, the nuclei (pl. V, fig. 29) exhibiting the picture of chromatolysis. Also the erythrocytes of the shark degenerate rather numerously round the offshoots of the parasite (pl. V, fig. 31); they attain an irregular shape, and seem to be dissolved. A similar picture is afforded by the leucocytes (pl. V, fig. 30). — As is well known it is a general rule that the attack of a parasitic organism is answered in the host by an influx of leucocytes to the place of attack. We should thus also in *Etmopterus* expect a larger amount of leucocytes in the degenerating tissues, or near them. As a matter of fact, several leucocytes are observed in the parts concerned, but their number was nevertheless astonishingly small. This must be due to the rapid dissolution of the shark's tissues in the environs of the filaments of the parasite. This dissolution clearly appears from the mentioned signs of degeneration which predominate in the tissues of *Etmopterus* round the filaments of *Anelasma*. We have here a sure proof that *Anelasma* also absorbs nutriment from the body of the shark through the filaments of its peduncle.

The absorbtion of food through the filaments has of course set its mark upon the digestive organs of *Anelasma*. Even though the digestive organs proper according to their high organisation cannot be judged as unimportant in the animal's life, their finer structure seems to evince a rather reduced function. The investigation of the fullgrown specimens has in all cases demonstrated intestinal cells in rest, and also the digestive glands consist of cells which exhibit an indifferent if not directly degenerated appearance. If we moreover compare the muscles of the alimentary canal in *Anelasma* with those of *Scalpellum*, we find that especially the proctodæum of *Anelasma* is strikingly sparsely endowed with muscles; this also speaks in favour of the supposition of a subordinate importance of the alimentary canal as a digestive organ. It is at present impossible to give a definitive answer as to the part played by the intestine in the life history of the fullgrown *Anelasma;* we have nevertheless reason to believe that its maintenance, or better, its rather high development, is due to its importance as an excretory organ. Even though indisputable renal organs are found in the proboscoidal part of the animal, they cannot make an excretory intestinal organ superfluous.

Turning again to the filamentary appendages of the peduncle, we have to answer the question, where do the supposed dissolving secretions originate, which influence the tissues of the host? The tissues of the filaments themselves contain no gland cells, and the

same might at first seem to hold good for the lacunary tissues, through which the nutritive fluids pass throughout the body of *Anelasma*. A closer study nevertheless reveals gland cells in the mesodermal, connective tissues of the parasite, viz. the cementary gland cells. — In *Scalpellum* the cementary glands gather into two aggregates, sending their secretions through two separate main ducts down to the base of the peduncle. In *Anelasma*, the cementary glands are more numerous, and spread over the basal parts of the mantle and the upper part of the peduncle; it is here impossible to speak of definite aggregates of gland cells, or glands, and it was impossible to trace their ducts farther down the peduncle; quite on the contrary, the short ducts from the single gland cells seem to open into the lacunæ of the connective tissue. The comparatively large number of cementary glands, and the extraordinary size of the single gland cells in *Anelasma*, point to their playing a great part in the life history of the animal, and this part cannot be the secretion of a cementing substance as supposed in other cirripeds. GRUVEL (1905) also attributes to the cementary glands other secretorial functions, and his supposition would so far give a good explanation of their great quantity in *Anelasma*, especially if it could be demonstrated that their secretions stand in connection with the dissolving faculty of the filaments as against the tissues of the shark. The different results of the staining methods stated above also show a different nature of the secretorial function of the cementary glands in *Scalpellum* and *Anelasma;* it seems indisputable that this must stand in connection with the parasitic mode of life in the latter.

The cementary gland cells, as mentioned, are comparatively large in *Anelasma*. In this respect they markedly contrast with the remaining somatic cells of the animal, which are not only comparatively, but also absolutely smaller than in *Scalpellum*. This feature is the more interesting because the latter species is the smaller one, and it may possibly be taken as an evidence of the more primitive position of *Scalpellum*.

Summary.

A short review of the investigations gives as main results that *Anelasma*, in the coarser organisation of its alimentary canal, takes up a rather intermediate position between the lower organised *Scalpellum*, and the somewhat more highly specialized *Conchoderma*, and *Lepas*. The digestive glands of *Anelasma* are in their coarser anatomy more highly developed than in *Scalpellum*, and somewhat approach highly organized species as *Conchoderma;* on the other hand, their finer structure conveys the impression of resting, or even degenerating tissues. The digestive intestine proper

also seems to have suspended its function as a food-absorbing organ. This depends upon the development of secondary nutritive organs, viz. the offshoots or filaments of the peduncle. These filaments are probably supported in their dissolving influence on the shark's tissues by secretions from the cementary glands, the latter being numerous and of great size in *Anelasma*. The cementary glands do not here, as in other pedunculate cirripeds, gather into two groups, or send their secretions to the base of the peduncle through two main ducts. The single gland cells communicate through short ducts with the lacunes of the connective tissue *in Anelasma*.

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Explanation of the plates.

Plate I.

Anelasma squalicola.

Fig. 1. Two specimens in situ at the dorsal fin of an *Etmopterus*, Nat. size.

» 2. Sagittal section of the thorax [× 5]. S = stalk; I to VI the six left cirri; P = penis; m = mouth opening; oe = oesophagus; s = stomach; i = digestive intestine; p = proctodæum; a = anus.

» 3. Part of a transverse section of the oesophagus [× 320]. c = cuticle; r = ring muscle. BOUIN. Boraxcarmine, bleu de Lyon.

» 4. Part of a transverse section of the oesophagus, showing the connection of the dilatatory muscles with the cuticle [× 320]. BOUIN. Boraxcarmine, bleu de Lyon.

» 5. Longitudinal section of the alimentary canal at the transition from the stomach (s) to the digestive intestine (i). [× 320]. RABL. WEIGERT'S haematoxyline—iron ammonium sulphate, VAN GIESSON.

» 6. Epithelium from the digestive intestine [× 460]. RABL. WEIGERT'S haematoxyline—iron ammonium sulphate, eosine.

Plate II.

Anelasma squalicola.

Fig. 7. Epithelium from the proctodæum [× 460]. BOUIN. Boraxcarmine, bleu de Lyon.

» 8. Entrance of the duct from the digestive gland into the digestive intestine in a quite young specimen. At ×, the transition from glandular into intestinal epithelium. [× 320]. RABL. WEIGERT'S haematoxyline–iron ammonium sulphate, VAN GIESSON.

» 9. Section of the digestive gland in the same specimen. [× 460]. RABL. WEIGERT'S haematoxyline–iron ammonium sulphate, VAN GIESSON.

Fig. 10. Epithelium from the digestive gland of a fullgrown specimen [× 460]. RABL. WEIGERT's haematoxyline–iron ammonium sulphate, VAN GIESSON.

» 11. Transverse section of a filament of a young specimen at some distance from the peduncle [× 320]. RABL. WEIGERT's haematoxyline–iron ammonium sulphate, VAN GIESSON.

» 12. Transverse section of a filament of the same specimen at its distal end, surrounded by the sharks tissue [× 320]. RABL. WEIGERT's haematoxyline—iron ammonium sulphate, VAN GIESSON.

Plate III.

Anelasma squalicola.

Fig. 13. From a transverse section of the mantle of a quite young specimen. c = cementary gland cell [× 460]. RABL. WEIGERT's haematoxyline—iron ammonium sulphate, VAN GIESSON.

» 14. Transverse section of a cementary gland cell of a fullgrown specimen [× 320]. RABL. WEIGERT's haematoxyline —iron ammonium sulphate, VAN GIESSON.

» 15. Section of a cementary gland cell of a fullgrown specimen showing the duct in longitudinal section. [× 320]. RABL. WEIGERT's haematoxyline—iron ammonium sulphate, VAN GIESSON.

Scalpellum Strømii.

» 16. Section through the end part of a cementary gland [× 460]. BOUIN. DELAFIELD's haematoxyline, eosine.

Plate IV.

Scalpellum Strømii.

Fig. 17. Longitudinal section of the oesophagal wall. c.p. = connective parts between the cuticle (c), and the dilatatory muscles (d. m.); r. m. = ring muscle [× 460]. BOUIN. DELAFIELD's haematoxyline, eosine.

» 18. Longitudinal section of the alimentary canal showing the transition from the stomach (s) to the digestive intestine (i) [× 320]. BOUIN. DELAFIELD's haematoxyline, van GIESSON.

» 19. Section of the «salivary gland» [× 460]. BOUIN. WEIGERT's haematoxyline—iron ammonium sulphate.

» 20. Epithelium of the digestive gland; resting phase [× 460]. BOUIN. DELAFIELD's haematoxyline, eosine.

Fig. 21. Epithelium of the digestive glands; cells in function [× 460]. BOUIN. WEIGERT'S haematoxyline—iron ammonium sulphate, eosine.

Plate V.

Anelasma squalicola.

Fig. 22. Epithelium of the digestive intestine [× 460]. BOUIN. Boraxcarmine, bleu de Lyon.

» 23. Epithelium of the digestive gland [× 460]. BOUIN. Boraxcarmine, bleu de Lyon.

» 24. Cementary gland cell [× 320]. BOUIN. Boraxcarmine, bleu de Lyon.

Scalpellum Strømii.

» 25. From a transverse section of the oesophagus [× 320]. BOUIN. Boraxcamine, bleu de Lyon.

» 26. Epithelium of the digestive intestine [× 320]. BOUIN. Boraxcarmine, bleu de Lyon.

» 27. Epithelium of the digestive gland [× 320]. BOUIN. Boraxcarmine, bleu de Lyon.

» 28. Part of a section of the «salivary gland» [× 320]. BOUIN. Boraxcarmine, bleu de Lyon.

Etmopterus spinax.

» 29. Degenerating nuclei of the connective tissue surrounding the filaments of *Anelasma* [× 600]. BOUIN. DELAFIELD'S haematoxyline, eosine.

» 30. Degenerating leucocytes [× 600]. BOUIN. DELAFIELD'S haematoxyline, eosine.

» 31. a normal erythrocyte; b degenerating erythrocyte [× 600]. BOUIN. DELAFIELD'S haematoxyline, eosine.

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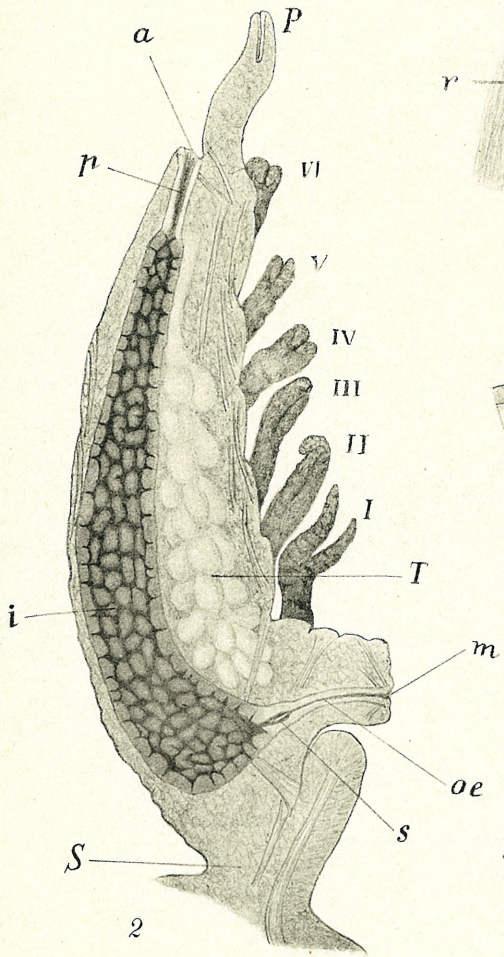

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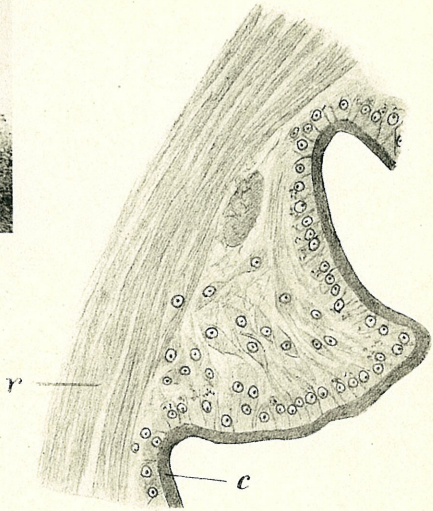

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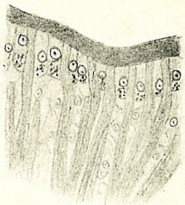

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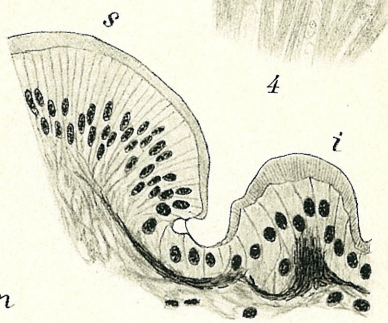

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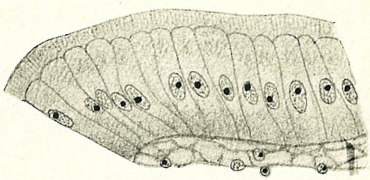

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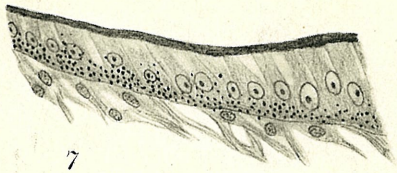

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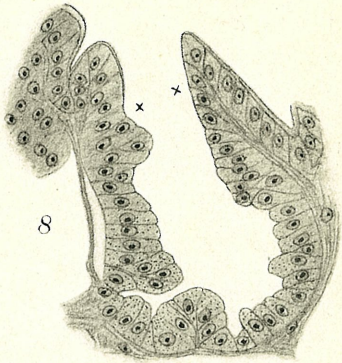

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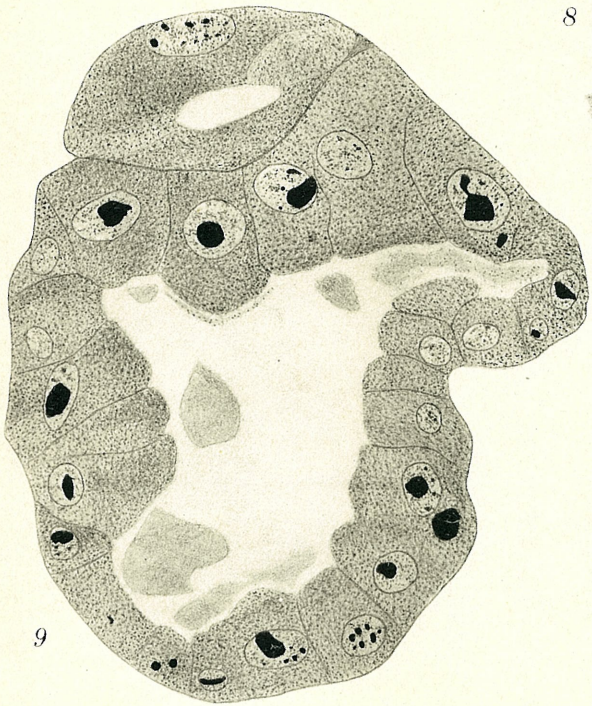

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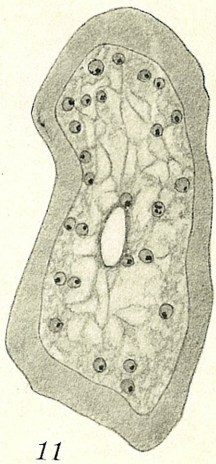

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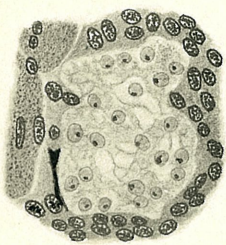

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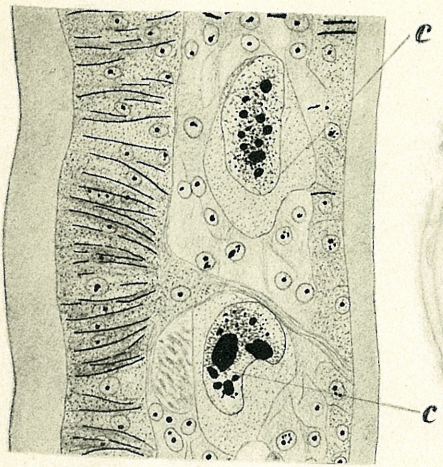

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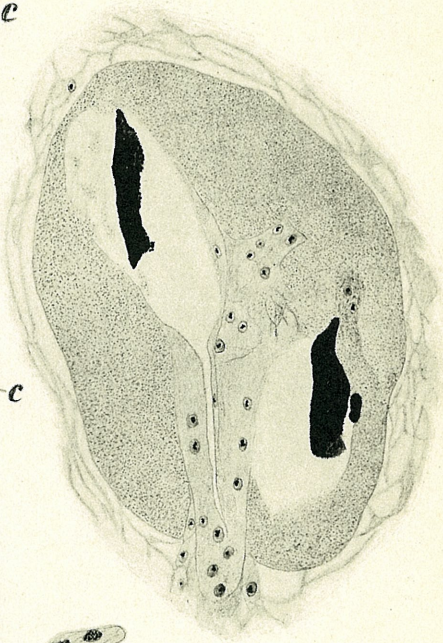

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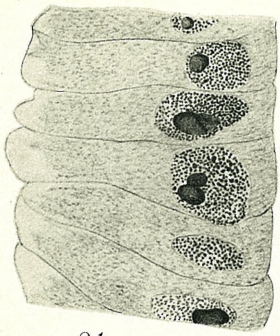

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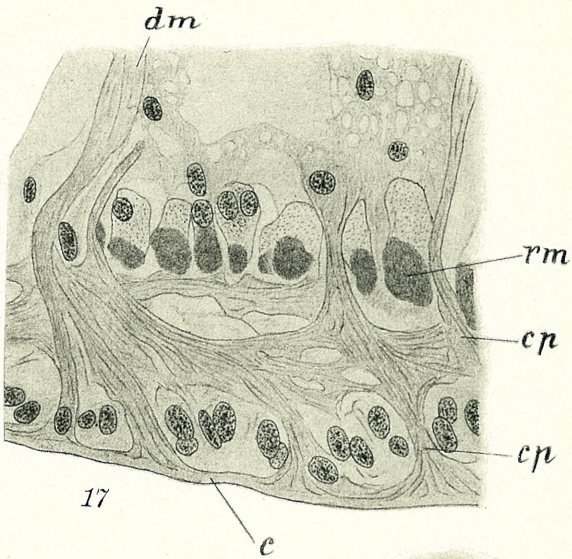

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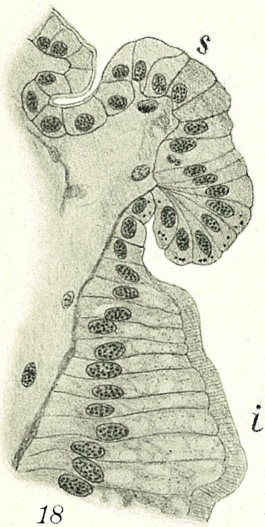

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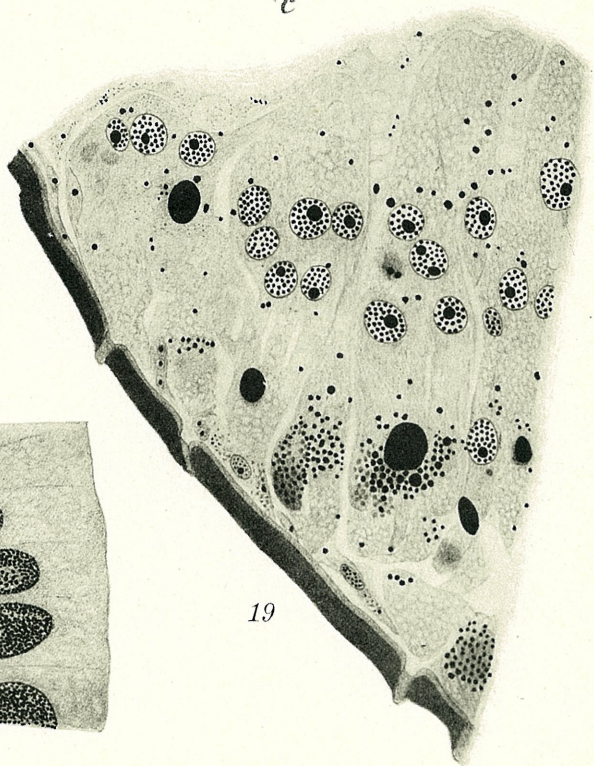

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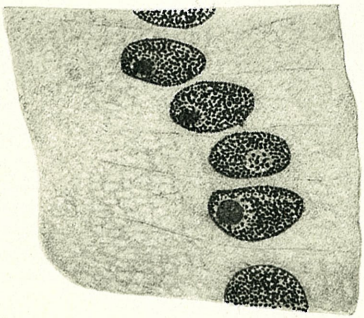

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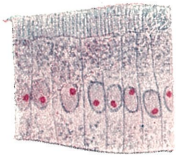

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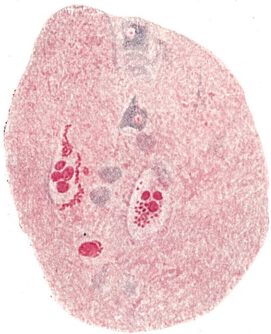

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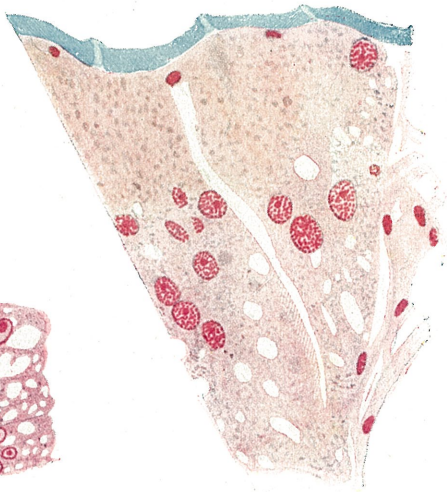

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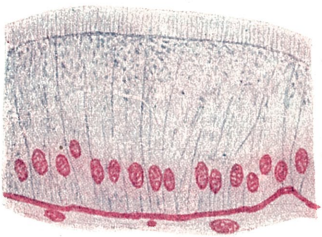

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