Coincidences of Vanadium Lines with Lines of other Metals.

λ (Kensington).	Origin of coincident line.	Int. in V.	Int. of coincident line.	λ (Kensington).	Origin of coincident line.	Int. in V.	Int. of coincident line.
3894·16	Cr	4–5	4	4427·49	Fe	4	7
3913·71	Fe	1	2–3	67·09	Co	2–3	4
77·88	Fe	2	4–5	97·00	Cr	4	5–6
4052·60	Mn	1	4	4514·36	Fe	4	< 1
68·16	Fe | Mn	2–3	3 | 5	17·75	Fe	3	1
70·94	Fe	2–3	2–3	25·33	Fe	3–4	4
83·07	Mn	3–4	7	34·08	Co	3	4
90·05	Mn	1	4	49·79	Co	6	5
90·74	Mn	8	1–2	4603·15	Fe	1	5
4224·36	Fe	3–4	3	26·66	Mn	4–5	5
34·18	Co	5–6	1–2	54·80	Fe	1	4
4408·35	Mn	5	4	4709·93	Mn	2–3	7
15·25	Fe	3	10	4871·50	Fe	2	6

"A Preliminary Account of the Development of the Free-swimming Nauplius of *Leptodora hyalina* (Lillj.)." By Ernest Warren, D.Sc., Assistant Professor of Zoology, University College, London. Communicated by Professor Weldon, F.R.S. Received February 4,—Read February 28, 1901.

Leptodora appears to be a primitive daphnid in retaining a long, markedly segmented abdomen, and for this reason it seemed likely that an investigation on the development of the winter-generation might throw some light on the vexed questions in Crustacean development. It was more particularly desired to ascertain whether any vestige of a cœlom occurred, and that if so, whether any remnant of it persists in the adult. With this object in view, it was necessary to inquire into the origin of the genital cells and of the antennary and maxillary glands.

In April, 1898, Professor Hickson obtained a few nauplii from Lake Bassenthwaite, Cumberland, and later in the year a large number of adults. This material was most generously placed at my disposal by Professor Weldon, and I wish to express to him my sincere thanks.

The material was insufficient for my purpose; and in the following spring I visited Lake Bassenthwaite to try to obtain fresh material, but I met with very little success. Last spring, however, sufficient material was obtained to continue the investigation.* The preserving reagent employed was Flemming's solution (strong formula).

* I am indebted to the Royal Society for a Government Grant in connection with obtaining this material.

Fig. 1 represents the youngest nauplius tow-netted. It should be noticed that Ant. 1 is not a swimming appendage. The posterior end of the body is rounded, as the characteristic caudal forks are not yet developed. The mandible already possesses the rudiment of a biting blade. The first and second maxillæ are represented by the merest rudiments. Thoracic legs 1–6 are present as conspicuous buds. The lower lip is not yet developed.

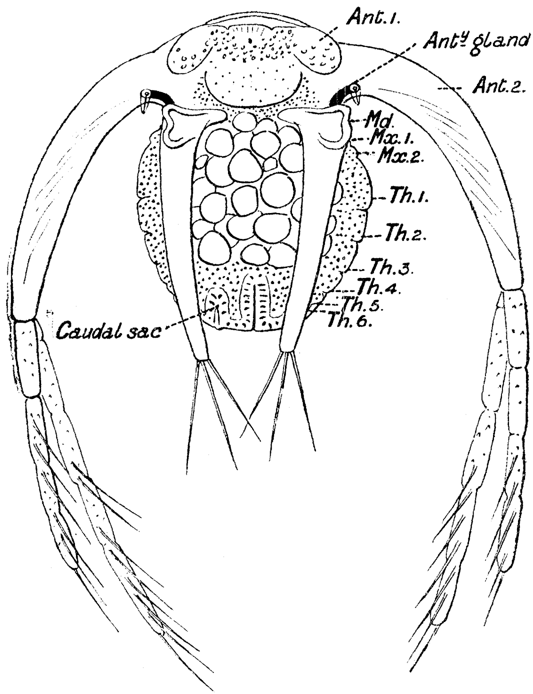


FIG. 1.—Ventral view of the youngest nauplius. Ant. 2 is relatively much longer than at any other period of life. × 110 diameters.

On each side of the proctodæum there is a little ectodermal pit secreting a cuticular (?) substance. In an older nauplius, a prominent spine projects out of these sacs, which are then situated at the ends of the caudal forks (fig. 2). These ectodermal pits bear a strong resemblance to the setal sacs of a Chætopod.

At this time the mesenteron has an incomplete lumen, but both the stomodæum and proctodæum have reached it.

Above the gut there is a large collection of yolk-masses surrounded by a membrane of flattened yolk-digesting cells which send processes inwards between the yolk-masses. There is no yolk-sac duct.

In an older nauplius the biting blades of the mandibles are more

developed, and at every future moult the swimming ramus gradually becomes shorter. Relatively the mandibles travel somewhat forwards, so as to be situated nearer to the mouth. The rudiment of the second maxilla is just visible, that of the first maxilla is only seen in a horizontal section of the embryo.

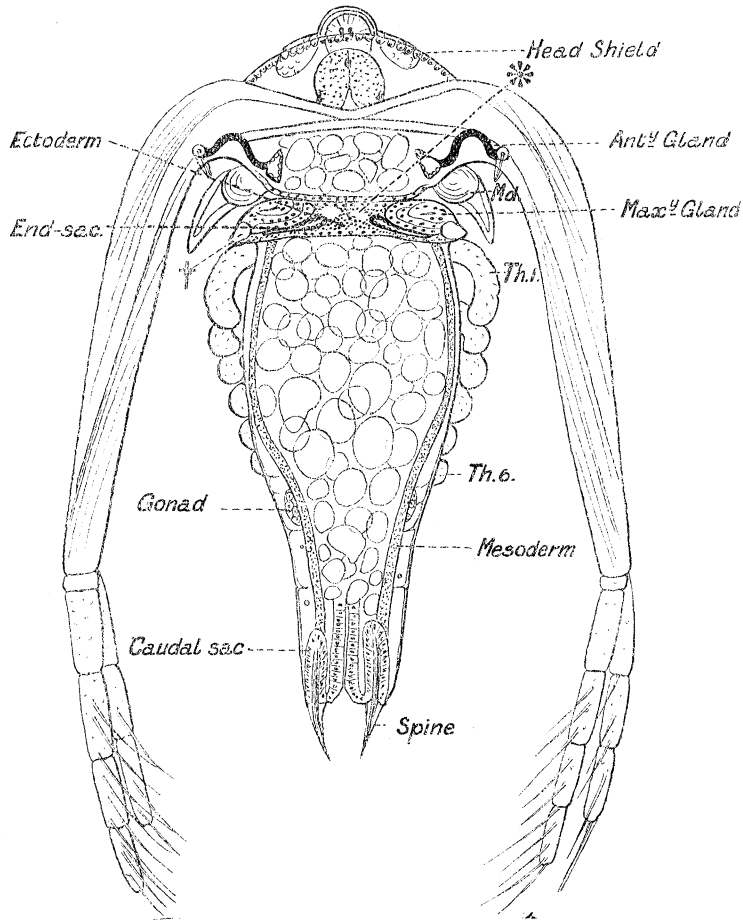


FIG. 2.—Dorsal view of metanauplius. The embryonic carapace, formed by the fusion of the two dorso-lateral swellings, is gradually extending backwards over the thorax. × 110 diameters.

In these nauplii, I met with a remarkable instance of unequal development in the different organs. Several nauplii which were presumably older than those with a rounded posterior end (since they were somewhat larger and possessed caudal forks) were, nevertheless,

much less advanced in the development of the internal organs. The subject of variation *in time*, and the partial independence of the different organs in development, would seem to be well worthy of more attention than has been paid to it.

The lower lip appears late; it seems to originate from paired rudiments; but the slight papillæ representing the maxillæ do not enter into its formation, for they flatten out and disappear.

The characteristic shape of the adult thorax, whereby the ventral surface bearing the legs comes to be situated nearly at a right angle to the head, is not assumed, as we might have expected, until the adult structure is attained.

Even in the quite young nauplius the ectoderm over the head is curiously modified; the cells are large and possibly glandular or excretory in nature. They possess large nuclei towards their bases and are much taller than the ordinary ectoderm cells. In the adult animal, these cells form a large patch over the head, the "Kopfschild" of Weismann (fig. 2). I have not detected anything else of the nature of a "dorsal organ," and I suggest that the above-described structure represents it.

As the youngest nauplius captured was a free-swimming creature with many muscles, it might have been anticipated that anything of the nature of segmental cœlom pouches, if present, would be much obliterated. Most of the mesoderm consists of a fairly uniform sheet of cells lying on each side of the gut. Posteriorly the mesoderm is more abundant and compact. The muscles of the thoracic legs are formed from the base of the mesoderm bands (fig. 3, B). The cells

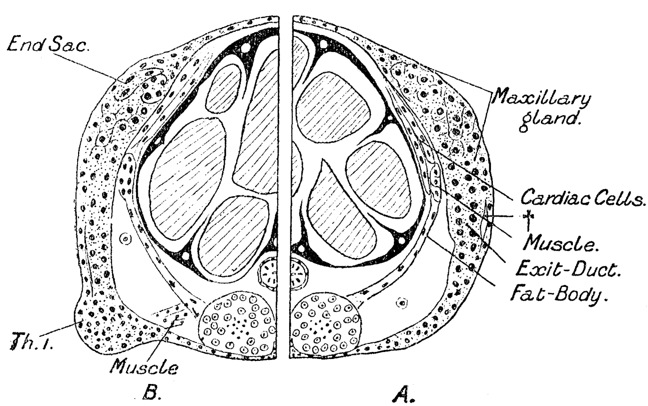


FIG. 3.—A. Cross-section of a young nauplius just behind the rudiment of 2nd maxilla. The exit-duct of the maxillary gland can be seen passing up into the dorso-lateral swelling.

B. Cross-section of a slightly older nauplius; it is a little posterior to A. Differentiation of end-sac and part of glandular tube can be seen in the dorso-lateral swelling.

which will form muscle, are considerably larger than the rest of the mesoderm cells and stain more deeply; they become arranged in parallel cords. By the arrangement of the primitive muscle, the segmentation of the abdomen is marked out quite early in the life of the nauplius.

The cells which will form the heart, can be distinguished at an early period. In the thoracic region, the dorsal portion of the mesoderm bands consists of two closely applied layers of flattened cells (fig. 3). These layers gradually grow up over the yolk-sac, and those of one side meet their fellows of the other side in the mid-dorsal line. Separation of the two layers now occurs, and the sac thus formed is the heart (figs. 4 and 5). The pericardial space originates by two processes—

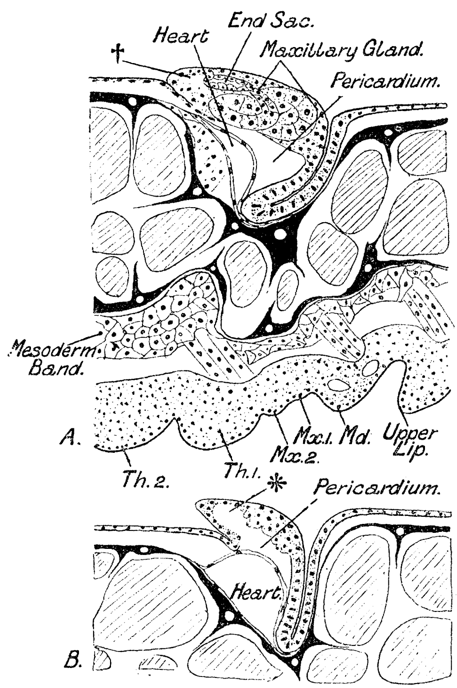


FIG. 4.—A. Longitudinal vertical section through the dorso-lateral swelling; it is taken at some distance from the mid-dorsal line (see fig. 2).
B. Similar section taken close to the mid-dorsal line.

1) the gradual separation of the ectoderm from the heart-sac, and (2) the disintegration of the deeper layers of this thick ectoderm (figs. 2, 4, 5, *). There appears to be a definite floor to the pericardial space, consisting of flattened cells continuous with those of the heart (fig. 5, B), but the roof would seem to be simply the general dorsal ectoderm of the thorax.

The blood-corpuscles are large and frequently spherical. I think it is probable that they are budded off from the compact mesoderm at the posterior end of the body, but it is very difficult to be certain about their origin.

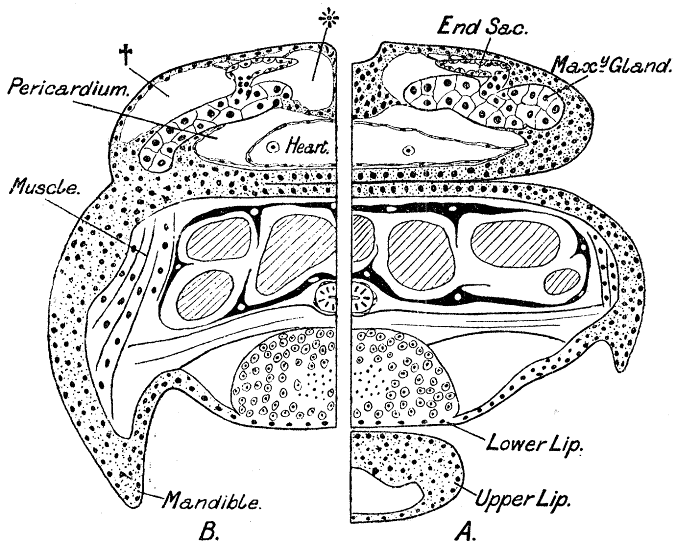


FIG. 5.—A. Obliquely transverse section through the dorso-lateral swelling of a metanauplius. The maxillary gland has become sharply differentiated from the imbedding ectoderm.

B. Similar section through an older metanauplius; the space marked † has developed. The space * will soon become continuous with the space around the heart.

In the earliest nauplius obtained the gonad is quite definitely formed. Without doubt the generative cells originate exceedingly early, probably they could have been distinguished in the blastosphere stage as Grobben has described in the case of Moina. The ovary becomes surrounded by a layer of mesoderm, and the generative duct seems to be solely mesodermal. The main mass of the mesodermal bands becomes converted into the characteristic double-layered fat-body lying on each side of the gut.

The origin of the antennary and maxillary glands has very considerable morphological interest, and I have devoted much care in endeavouring to elucidate it. The development of the maxillary gland will be described first.

On the lateral sides of the body of my youngest nauplius, just posterior to the vertical plane passing through the second maxilla, the ectoderm is several layers thick. This thickening is more pronounced dorsally, and on surface view of the nauplius we can see a distinct dorso-lateral

swelling on each side. In the lateral thickening of ectoderm, a band of cells passes nearly vertically downwards to the papilla representing the second maxilla. The band will become the exit-duct of the future gland; the band extends upwards into the dorso-lateral swellings mentioned above (fig. 3, A). It is out of these swellings that the rest of the gland becomes differentiated.

Fig. 3. B is a cross-section a little posterior to A, and is taken from a nauplius very slightly older. Here the end-sac can be seen vaguely marked out from the surrounding ectoderm.

The lateral swellings containing the developing glands gradually extend upwards, and after a time they meet together in the mid-dorsal line (fig. 2).

There is formed simultaneously a deep transverse groove in front of the upgrowing swellings, and a less conspicuous groove occurs behind (fig. 4, A and B).

The overhanging portion of the embyonic carapace (fig. 4, B) will be carried backwards as the animal develops, and will, in the female, expand into the free portion of the carapace overhanging the first two abdominal segments.

As the fused swellings (the embryonic carapace) gradually extend backwards over the dorsal surface of the thorax, the maxillary gland is drawn out with them into the position and shape seen in the adult.

At the same time there is a general expansion of the parts; the maxillary gland begins to separate itself from the surrounding ectoderm (figs. 2, 3, 4, and 5, †), and the space around the heart gradually increases. There is also a certain amount of disintegration of the ectoderm where the dorso-lateral swellings met in the middle-line. The spaces marked * in figs. 2, 4 and 5 are thus formed, and ultimately they become continuous with the space around the heart.

We have already seen that this pericardial space has a definite floor of flat mesoderm cells, but the roof would seem to be simply the ectoderm of the body-wall. The exit-duct with the external opening travels upwards into a dorso-lateral position, so that in the adult it is nearly horizontal.

In the material at my disposal it is not possible to decide for certain whether the antennary gland also arises from the ectoderm, but it is highly probable that it does so.

Fig. 6. A, B, C represent three stages in the growth of this structure. The nuclei in the intracellular duct, and connected ectoderm have been carefully put in the diagrams from actual sections, and their arrangement certainly gives the impression that the duct should be regarded as an ingrowth of ectoderm.

Fig. A represents the condition observed in the youngest nauplius. The end-sac consists of fairly large cells which are not very different in character from the cells forming the intracellular duct. At a slightly

later date (fig. B), the cells of the end-sac have become smaller, and there is a more distinct basement membrane; they greatly resemble the cells of the end-sac of the maxillary gland. In an older nauplius (fig. C) the intracellular duct begins to disintegrate, but the end-sac remains adhering to the dorsal ectoderm for a very considerable time; ultimately, however, it disappears.

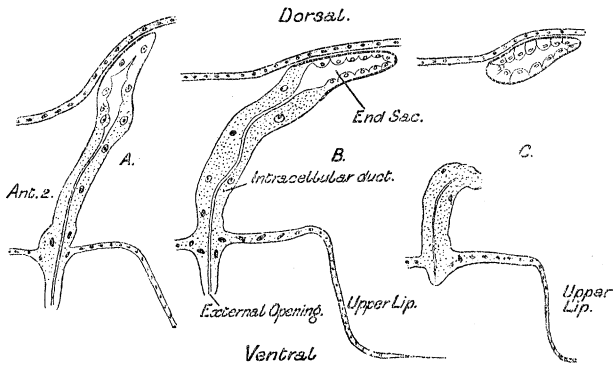


FIG. 6.—A. The antennary gland seen in transverse section through the youngest nauplius at the level of the 2nd antenna.

B. The same gland seen in a slightly older nauplius. The cells of the end-sac are smaller, and there is a more definite basement membrane.

C. The same in an advanced metanauplius. The intracellular duct no longer communicates with the end-sac.

According to these observations, the maxillary and possibly the antennary glands are purely ectodermal in origin, and the end-sac is to be looked upon as merely a terminal thin-walled dilatation of the glandular tube. At one time I believed that mesoderm crept up behind the maxillary gland (see fig. 4, A), and formed the end-sac, but renewed observation convinced me that it is formed out of the ectoderm in *direct continuity* with the glandular tube (see fig. 3, B).

It appears from recent observations that the nephridia of Chætopods should be regarded as ectodermal tubes which generally open into a cœlom, and sometimes may come into connection with a generative funnel. In a trochosphere (*e.g.*, in that of Polygordius), the "head-kidney" is probably budded off from the ectoderm, and since there is no cœlom into which it can open, the tube terminates in a slightly dilated "flame-cell."

Although cœlom sacs are doubtless formed in the development of some crustacea, yet I altogether failed to discover any traces of them in the youngest nauplius of Leptodora that I have examined; and even in those cases where they have been described, it does not follow that the antennary and maxillary glands enter into relationship with these transitory cœlom spaces.

If an ectodermal origin of the antennary and maxillary glands be confirmed in crustacea generally, then we should be led to regard these structures as nephridia, which have lost their primitive connection with a cœlom, and the end-sac would be looked upon as equivalent to the "flame-cell" of a typical intracellular nephridium.

The above preliminary account, which has omitted all reference to the nervous system and sense-organs, is merely a summary of the results already obtained. I hope in a future publication to give a full account, containing careful drawings with the camera lucida.

"The Growth of Magnetism in Iron under Alternating Magnetic Force." By ERNEST WILSON. Communicated by Professor J. M. THOMSON, F.R.S. Received February 25,—Read March 28, 1901.

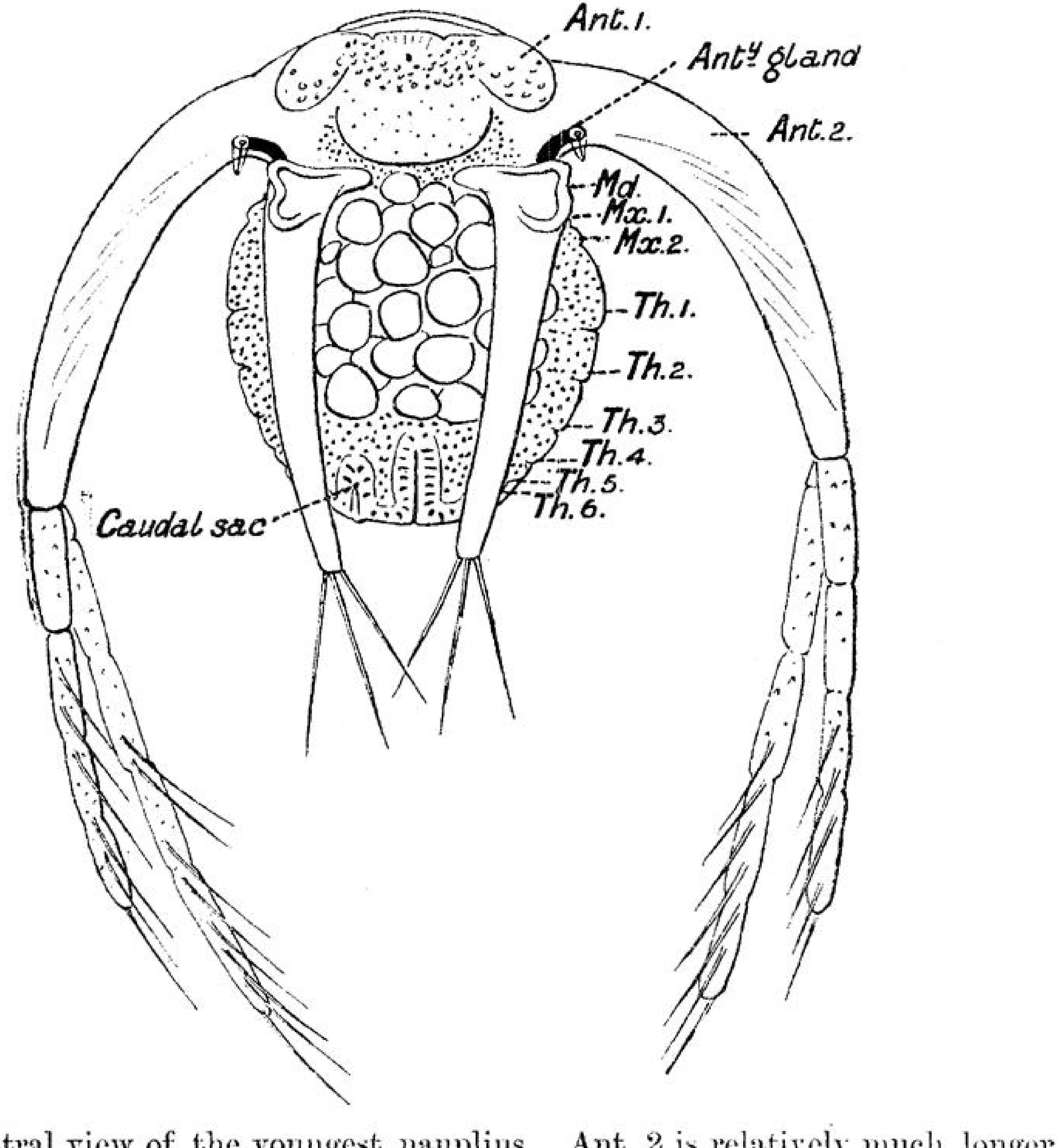
The object of this paper is to investigate the growth of magnetism in an iron cylinder when the magnetising force is alternating. The shielding effect of induced currents in plates of iron has been dealt with theoretically by Professor J. J. Thomson,* and Professor J. A. Ewing.† The subject has also been dealt with experimentally in the case of an iron cylinder, 4 inches diameter,‡ with alternating magnetising force and with simple reversal of the magnetising force. A cylinder, 12 inches diameter, has been experimented upon with simple reversal of magnetising force,§ and the shielding effect of induced currents studied. As the exploring coils enclosing elements of the cross-section of this 12-inch magnet are well suited to give the average induction density at four mean radii, the author thought the subject worth further investigation with regard to alternate currents. The magnet is of cast steel, and is shown in sectional elevation in fig. 1. A section of the 12-inch core on the line AA is given in fig. 2. Wires have been threaded through the holes drilled in the plane AA, enclosing the areas numbered 1, 2, 3, 4 (fig. 2), and another coil (No. 5) surrounds the core. A D'Arsonval galvanometer was placed in each of these five circuits with an adjustable resistance to control the maximum deflection. The deflections of the needles of the five galvanometers were noted simultaneously every four seconds, and were ultimately plotted in terms of time. The magnetising current in the copper coil of the magnet was observed simultaneously with the above on a Weston ampere meter. The current was made to alternate

* 'The Electrician,' vol. 28, p. 599.

† 'The Electrician, vol. 28 p. 631.

‡ Hopkinson and Wilson, 'Phil. Trans.' A, vol. 186 (1895), pp. 93–121.

§ Hopkinson and Wilson, 'Journal of the Inst. Elec. Eng.,' vol. 24, p. 195.



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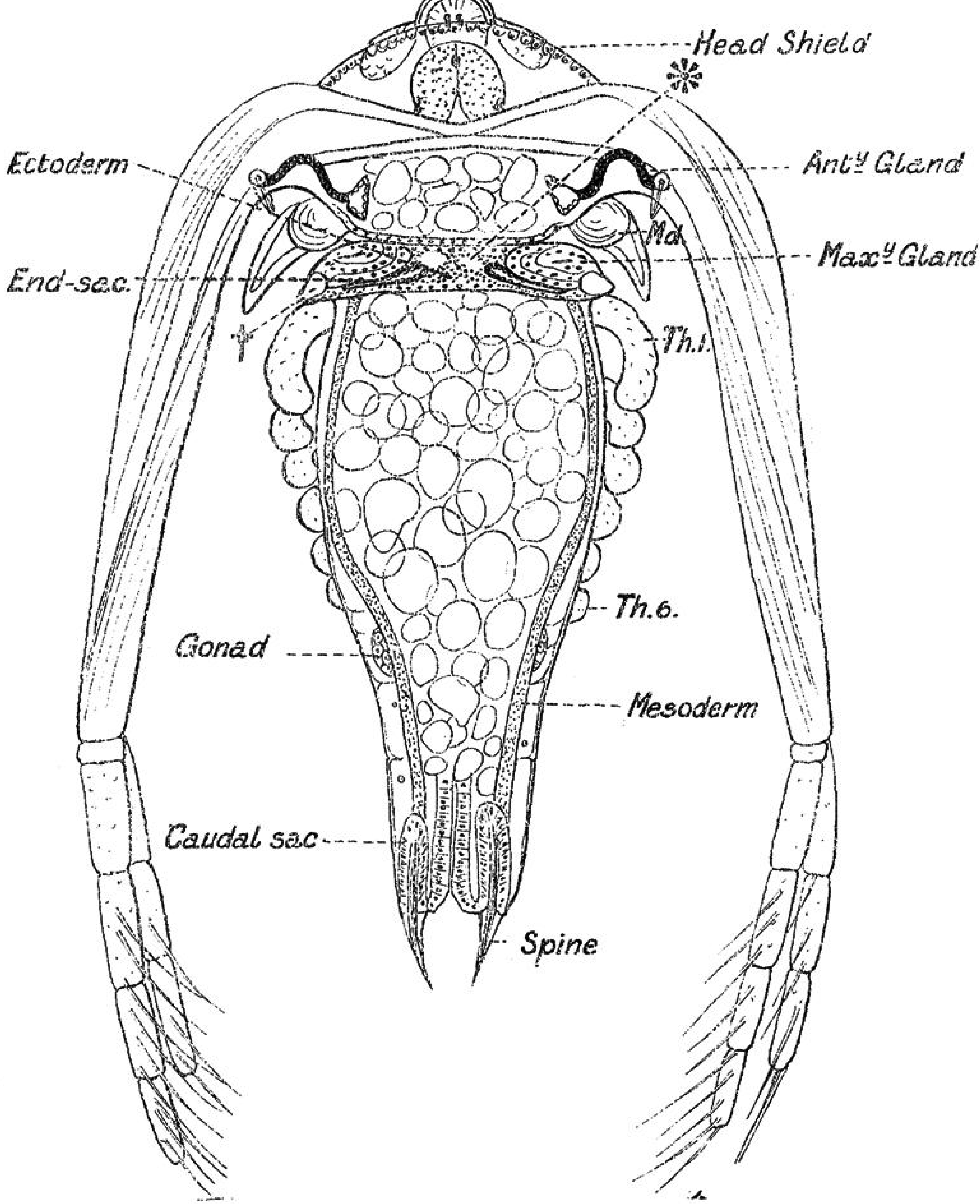

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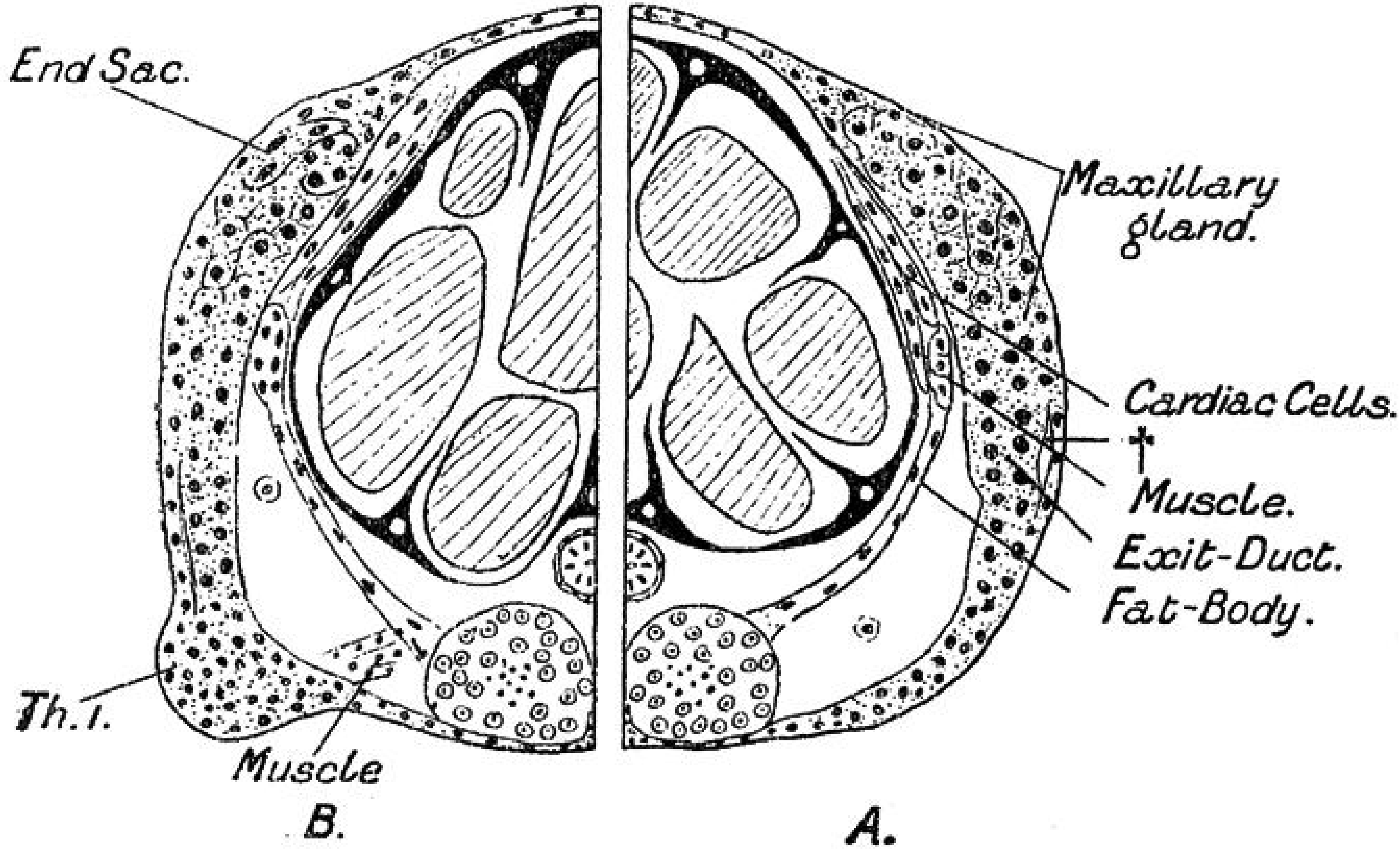

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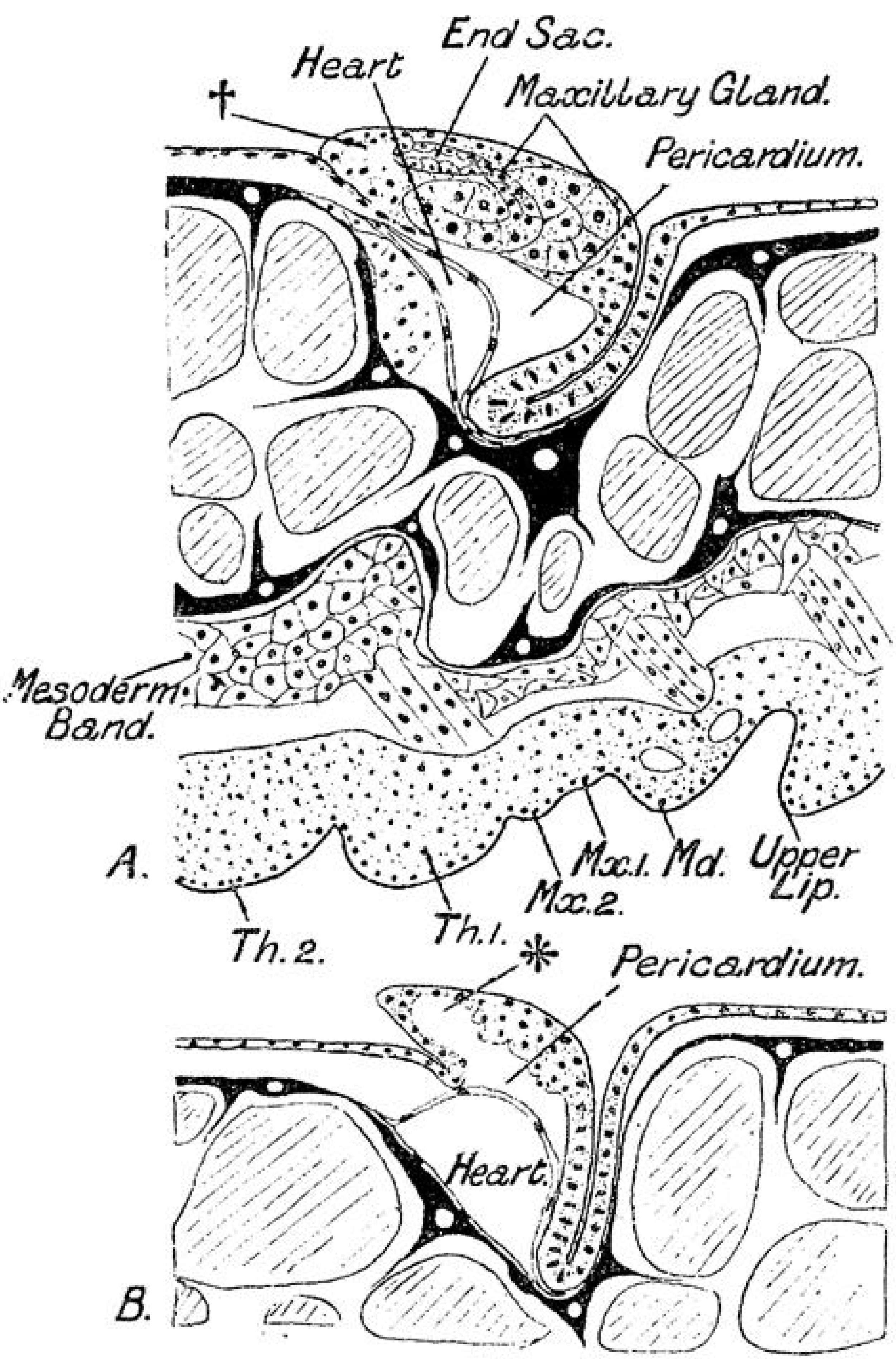

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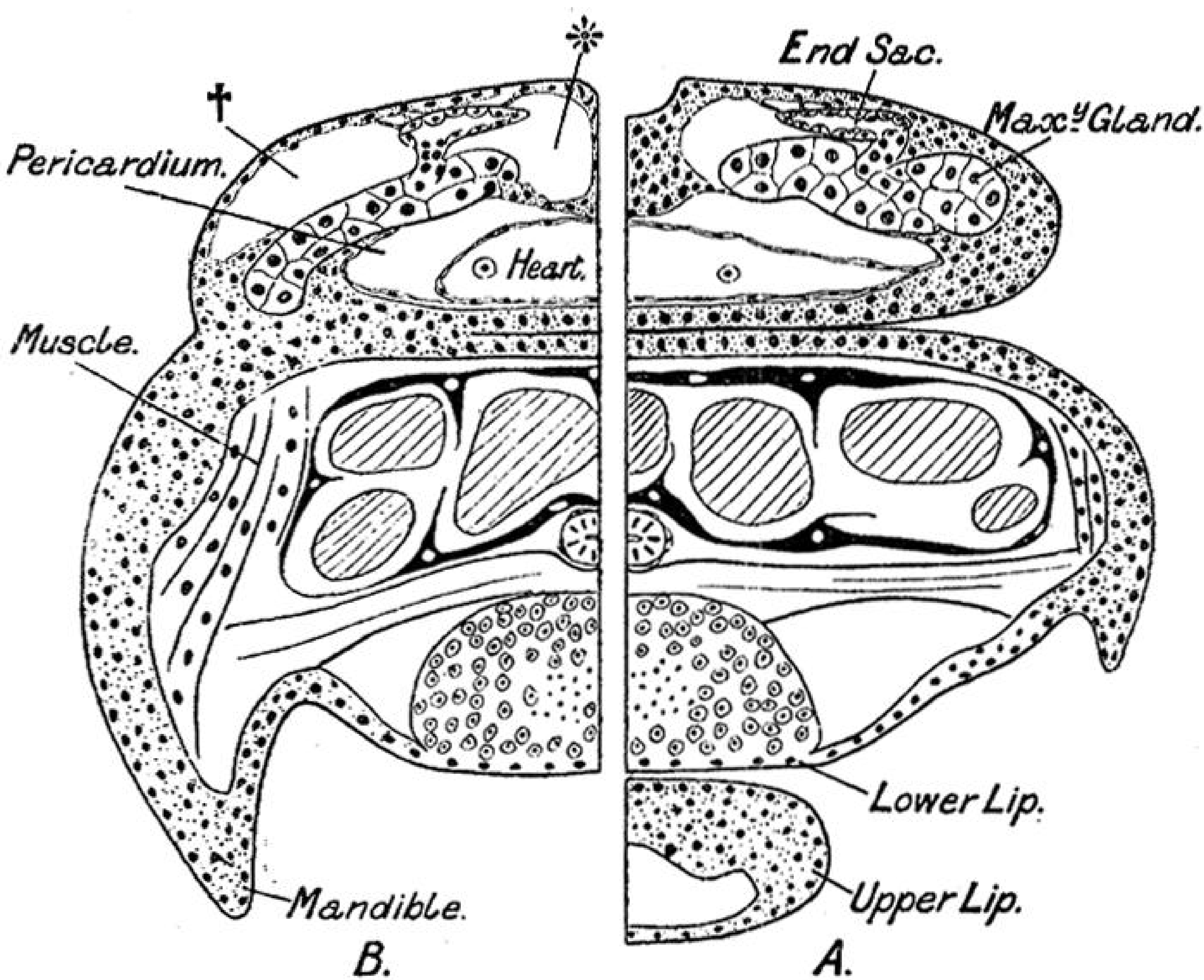

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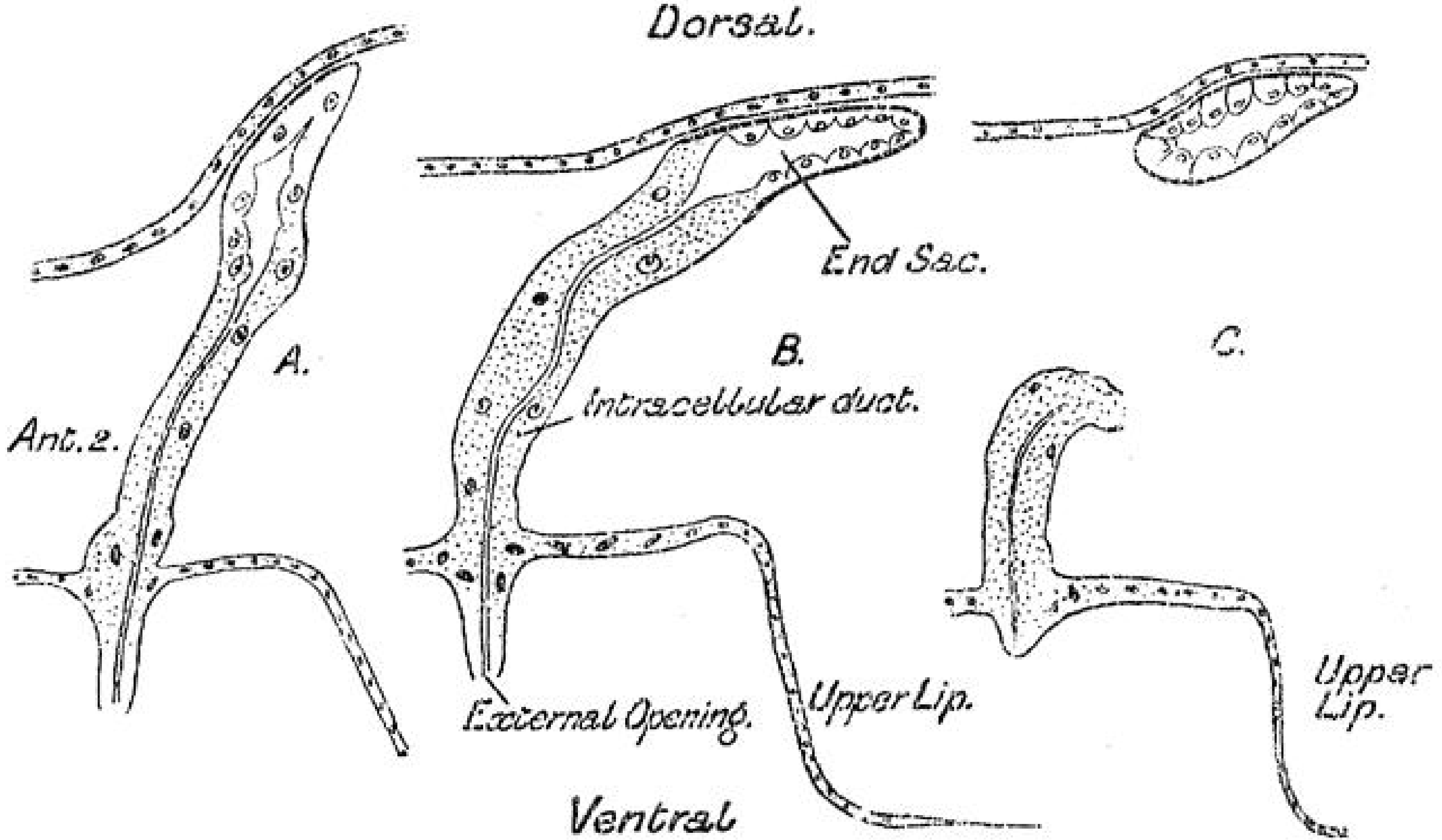

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