Art. XV.—*On an Australian Land Nemertine (Geonemertes australiensis, n. sp.)*

(With Plates VII, VIII, IX, X.)

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[Read July 9, 1891.]

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1. Introductory Remarks.

In the *Victorian Naturalist* for December, 1889, I recorded the discovery of three specimens of a terrestrial Nemertine at Walhalla, Gippsland, Victoria, and gave a brief description of the general appearance of the animal.* Being unable, at the time, to obtain access to Professor von Graff's paper on *Geonemertes chalicophora*,† which it was

* "Zoological Notes on a Trip to Walhalla," *loc. cit.* p. 132.

† "*Geonemertes chalicophora*, eine neue Landnemertine," Morphologisches Jahrbuch, Bd. V, 1879, p. 430.

supposed (though without any conclusive evidence) might be an Australian form, I refrained from naming the species. Recently, however, thanks to the kindness of Professor von Graff, Professor Haswell, Professor Spencer and Professor Howes, I have received several copies of the paper in question, and as there can no longer be any doubt that the species is perfectly distinct from any that have been previously described, and as I have since obtained an abundant supply of material from various localities, I have decided to give a detailed description of the new species in this place, under the name *Geonemertes australiensis*.

In addition to the gentlemen whose names are mentioned above, I desire also to record my indebtedness to the following for valuable assistance and material, viz.:— Mr. J. J. Fletcher, M.A., for the loan of two specimens of *Geonemertes* (sp. ?) from Tasmania and New South Wales respectively;* Mr. J. Bracebridge Wilson, M.A., Mr. E. F. J. Love, M.A., Rev. W. Fielder, Mr. C. C. Brittlebank, Mr. Shephard and Mr. Fiddian for specimens from various parts of Victoria; and Mr. T. Whitelegge, of the Australian Museum, Sydney, for most kindly photographing for me the plate illustrative of von Kennel's paper on *Geonemertes palaensis*,† which I have been unable to obtain.

2. Habitat and Distribution.

Geonemertes australiensis is a thoroughly cryptozoic‡ animal. The first specimen which I found was beneath a stone, but since then most of the numerous specimens discovered have been found under rotting logs. As might be expected the animal seems to like a tolerably damp situation, apparently it does not burrow in the earth but simply lies beneath its shelter. Since I first recorded it from Walhalla it has been obtained from the Otway Forest (Mr. Wilson and Mr. Love), Creswick (Mr. Fiddian), the Upper Yarra district (Professor Spencer),§ Narre Warren (Professor Spencer), Myrniong (Mr. Brittlebank) and the Fern Tree Gully district. The most remarkable discovery was that at Fern Tree Gully, on the occasion of an expedition made by the Field Naturalists' Club of Victoria, on March 14, 1891,

* *Vide* Proc. Linn. Soc. N.S.W., April 29, 1891.

† Arbeit. Zool.-Zoot. Inst., Wurzburg, IV., 1877-78.

‡ For explanation of this term *vide Victorian Naturalist, loc. cit.*

§ *Vide Victorian Naturalist*, March-April 1891, p. 179.

when we found dozens of specimens under fallen logs. It is a curious fact that on most carefully searching the same locality only a few weeks later (May 13) I was unable to find a single specimen.

Mr. Fletcher* has lately recorded the occurrence of land Nemertines also in Tasmania and New South Wales, but it is somewhat doubtful whether they belong to the same species as the Victorian specimens, though from the examination of the external characters which I have been kindly permitted to make I am inclined to believe that they do.

3. External Characters, Habits, and Methods of Preparation.

As it lies at rest, with the proboscis retracted, *Geonemertes australiensis* has very much the appearance of a slug or a small Planarian worm, and is very soft and slimy. When it begins to crawl, which it readily does on being disturbed, the body elongates until in large specimens it measures about 40 mm. in length by 2·5 mm. in greatest breadth. The anterior extremity is then seen to be rounded and perhaps slightly swollen into a head, the posterior extremity tapering gradually to a blunt point where the anus is situated. The ventral surface of the body, on which the animal crawls, is somewhat flattened.

The colour of the living animal is chiefly yellow, varying a good deal in shade, and lighter on the ventral than on the dorsal surface. Sometimes it is a translucent, waxy yellow, sometimes orange, and sometimes more brownish. Figure 1 represents a specimen from near the Wood's Point Road, painted from life. In this case the dorsal surface was brownish yellow edged on either side by a narrow band of creamy white continuous with the creamy white ventral surface. Usually there are no stripes but sometimes there is a brown median dorsal band, and in a specimen from Myrniong, which I take to belong to the same species, there were two narrow stripes of a darker brownish tint down each side of the mid dorsal line, the remainder of the dorsal surface being of the usual yellow colour. Sometimes, in large specimens, the sides of the body have a distinctly mottled appearance, due to the large ova showing through the skin. At the extreme anterior end of the body, on the

* *Loc. cit.*

head, is a single aperture, the common opening of the proboscis sheath and alimentary canal, or, to speak more exactly, the opening of the rhynchodæum. A little behind this aperture there is, on each side of the head and somewhat more towards the dorsal than towards the ventral surface, an irregular group of minute black specks, the eyes. The number of the eyes is probably not constant, and the size is certainly very variable; in one specimen examined there were about twenty in each group.

On the ventral surface of the head are situated the two very minute openings of the cephalic pits, one on either side of the middle line, but these are only recognisable in sections, though sometimes there appears to be a transverse groove, visible with a pocket lens, in which they probably lie (Fig. 3.)

The animal crawls normally with an even, gliding motion, much like a Planarian, leaving behind it a slimy track. The motion is probably due in part to muscular and in part to ciliary action, the proboscis being at the time completely withdrawn into the body. If the worm is irritated, however, the proboscis is suddenly shot out from the anterior end with wonderful rapidity. This proboscis is relatively of enormous size, being, even when shot out only to the normal extent, fully as long as the body of the worm, if not longer. After remaining out for an instant it is more slowly withdrawn and this eversion and withdrawal may be repeated several times in rapid succession. Frequently, however (Fig. 12), the proboscis breaks away from its attachment round the mouth of the proboscis sheath and remains attached to the body of the worm only by the retractor muscle, which appears as a long, narrow thread coming out from the opening of the rhynchodæum. When detached in this manner the proboscis is actually larger than the body of the animal. The colour of the everted proboscis is pure white and its surface is quite furry from the presence of innumerable little glandular papillæ, which secrete a sticky fluid. Under normal conditions the proboscis may probably be everted and withdrawn again for an indefinite number of times. When fully extended it adheres slightly to the surface on which it falls and hence, as a necessary consequence, when the proboscis is withdrawn again the body of the animal is pulled forwards over it. In this way the animal may progress, using the proboscis as a means of locomotion. In the case of *Tetrastemma agricola* von

Willemoes-Suhm appears to regard* this as a normal mode of locomotion. From my own observations I am inclined to regard it as accidental, and I think that the proboscis is normally used only as a weapon of offence or defence, probably for catching insects, but this I have not observed. As already stated, when the animal is crawling under ordinary circumstances the proboscis is entirely withdrawn into the body.

So much for the external characters of the living animal. Before passing on to describe the minute anatomy it may be as well to say a few words as to the methods of killing and preserving specimens. Unfortunately the animal is so large and opaque that it is difficult to study the internal anatomy satisfactorily in the living worm, and, owing to the extreme irritability of the proboscis and the delicacy of the whole organism, it is an unusually difficult matter to kill and preserve the animal in a satisfactory condition, for the violent movements of the proboscis are very apt to cause the body to break up.

The following are the results of a number of experiments which I made with a view to finding the best method of killing and preserving specimens :—

(*a.*) By suddenly immersing the living worm in strong methylated spirits. This is sometimes successful, but the proboscis is always more or less everted in the spirit and frequently the body breaks up.

(*b.*) By suddenly immersing in very dilute aqueous osmic acid. Only one specimen was tried ; the proboscis was everted and the body broke up badly.

(*c.*) By suddenly immersing in a cold saturated alcoholic solution of corrosive sublimate. This is fairly successful but the proboscis is always everted and sometimes the body breaks.

(*d.*) By pouring a hot aqueous solution of corrosive sublimate on the living worm. This kills the animal nearly instantaneously, with the body generally intact but the proboscis everted. The heat employed, however, can scarcely fail to injure the histology of so delicate an organism.

(*e.*) By first holding the worm in the vapour of chloroform for about half a minute. Hold the worm on a lifter or glass

* "On a Land-Nemertean found in the Bermudas," *Annals and Magazine of Natural History*, Series 4, Vol. XIII, 1874, p. 409.

slip over an open jar containing a little chloroform, the animal contracts to its normal resting condition and is rapidly stupefied. Then quickly plunge the stupefied worm into strong spirit, taking care not to let the surface of the body adhere to the lifter. The animal is thus killed and hardened while under the influence of chloroform and the proboscis is not everted at all nor does the body break up, but the worm retains when dead the normal resting position. In making use of this method it is important to leave the worm in the chloroform vapour for neither too short nor too long a time; if the former, it regains its activity in the spirit and everts the proboscis; if the latter, it dies and adheres to the lifter or glass slip on which it lies.

This last I find to be by far the most satisfactory way of killing and preserving specimens, and it is the only method known to me by which the proboscis can be retained within the body in its natural position. Of course other hardening fluids besides alcohol may be used after stupefying with chloroform vapour.

Frequently, however, it is very desirable to preserve specimens with the proboscis everted, and for this purpose I recommend methods *a.* and *c.*

My researches on the minute anatomy of *Geonemertes* were conducted chiefly by means of sections taken in three planes (horizontal, sagittal and transverse), stained with borax carmine or Kleinenberg's hæmatoxylin, and cut by the ordinary paraffin method. Both methods of staining should be employed, as the results obtained are very different in the two cases; hæmatoxylin, for example, brings out with wonderful distinctness the network of excretory tubules, which I failed to recognise in the specimens stained with borax carmine.

4. Minute Anatomy.

a. Epidermis and Sub-Epidermic Tissues.

The epidermis and subjacent tissues may be studied very satisfactorily in sections stained with borax carmine; hæmatoxylin I have found very unsatisfactory for this purpose.

The appearance of the epidermis in sections varies a good deal with the state of contraction of the particular part of the body which it covers. Frequently it is thrown into slight folds and sometimes it is so stretched that it becomes very much thinner than in its normal condition, while the component cells are much more difficult to make out.

In favourable preparations, however, the epidermis is seen, very clearly indeed, to consist of very slender, greatly elongated, columnar cells, placed closely side by side. (Fig. 9, *ep.*) Each cell is broadest at its outer end and tapers gradually to a fine point imbedded in the subjacent tissue. About the centre of each is an elongated, deep-staining nucleus. The outer surface of the epidermis is richly ciliated.

Beneath the epidermis is a well-developed layer of unicellular glands (Fig. 9, *gl. c.*) The gland-cells are pear-shaped, with the narrow ends pointing outwards. Each contains a small nucleus and a larger or smaller quantity of finely granular material. These gland-cells are much more numerous and contain much more of the granular contents, on the dorsal than on the ventral aspect of the body. There can, I think, be no doubt that they secrete part of the slime with which the surface of the body is covered.

Scattered between the gland-cells and amongst the tails of the epidermic cells are numerous small, darkly staining nuclei (Fig. 9, *nu.*), whose exact relations I have not been able to make out. Around and beneath the gland-cells we also see a quantity of very finely granular material which scarcely stains at all with borax carmine and which extends inwards to the circular muscle layer. This tissue (Fig. 9, *b. m.*), in which a few scattered nuclei are imbedded, evidently constitutes the basement membrane already frequently described by writers on Nemertean anatomy.

b. Muscular System.

Within the basement membrane there are two well-developed muscular sheaths completely investing the body, viz., an outer sheath of circularly disposed muscle fibres and an inner sheath of longitudinal ones. Between these two principal sheaths there is a very thin and delicate layer of diagonally disposed muscle fibres.

The outer, circular, muscle sheath (Figs. 6, 7, 8, 9, 10, *c. m.*) is well developed and of about equal thickness all round the body, it is not, however, nearly so thick as the longitudinal sheath.

The inner, longitudinal muscle sheath (Figs. 6, 7, 8, 9, 10, *l. m.*) is more strongly developed on the ventral than on the dorsal surface of the body, doubtless in relation to the crawling movements of the animal. In transverse sections it is very clearly seen to be broken up into blocks by small bundles of muscle fibres which run inwards from the circular sheath to the deeper parts of the body (Figs. 8, 24).

The layer of diagonal or oblique muscle fibres (Fig. 10, *o. m.*) is very thin and consists of two series of fibres crossing one another obliquely, just as in *Geoplana*,* only in a different position. This diagonal layer in *Geonemertes australiensis* is very clearly recognisable in tangential sections along the sides of the body, much as is represented in Figure 10, taken from a specimen stained with borax carmine. I should not like to say positively that it extends completely round the body, but it probably does, though I have not been able to detect it with certainty in the mid-dorsal and mid-ventral regions.

In the head-region there is a special and very important development of muscles in relation to the proboscis sheath (*vide* Figs. 2, 3, 4, 5, 6). At about the level of the centre of the cerebral ganglia the longitudinal muscle sheath splits into two layers, an inner and an outer. The outer layer (*l.' m.'*) passes forwards in the old position. The inner layer (*m. d.*), on the other hand, passes forwards and inwards to join the proboscis sheath at the place where the proboscis is attached to it, immediately in front of the cerebral ganglia and behind the mouth. There is thus formed a distinct muscular diaphragm (Figs. 2–6, *m. d.*), convex anteriorly, lying immediately in front of the cerebral ganglia and behind the mouth. The musculature of the proboscis and its sheath, with which this muscular diaphragm is continuous, will be described in dealing with those organs.

I have already mentioned that numerous small bundles of muscle fibres run inwards from the region of the circular muscle sheath through the longitudinal sheath to the deeper parts of the body. Many of these small bands unite together to form a series of strong dorso ventral muscular bands which run in a vertical direction between the lateral diverticula of the alimentary canal.

c. Alimentary Canal.

The alimentary canal agrees very closely indeed with that of *Geonemertes chalicophora*, as described and figured by

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* *Vide* Dendy "Anatomy of an Australian Land Planarian," Trans. Royal Soc. Victoria, 1889.

Professor von Graff.* The mouth, as already observed, is situate just in front of the cerebral ganglia, within the rhynchodæum (Fig. 6, *m.*) The alimentary canal, as observed by von Graff, is divisible into two sections, the œsophagus and the gut proper, which differ essentially in the character of their lining epithelium. The œsophagus (Fig. 6, *œs.*) is at first a very narrow and short tube, with thin walls (*œs.* 1), which passes obliquely backwards and downwards beneath the ventral commissure of the cerebral ganglia. Behind the ganglia it suddenly dilates into a large saccular structure with thick and folded walls (*œs.* 2), lying beneath the most anterior portion of the proboscis sheath; then it contracts again to form a straight, short, thin-walled tube (*œs.* 3) springing from the posterior dorsal region of the saccular portion. At its posterior extremity the straight, thin-walled tube joins the gut proper. The relations of the different regions of the œsophagus to one another and to the other organs of the body will be best understood by reference to Figure 6, representing a median longitudinal section through the anterior extremity of the body.

The wall of the œsophagus is made up of more or less elongated, darkly staining, nucleated and richly ciliated columnar cells, and the transition from this epithelium to that of the gut proper is a very sudden one (Fig. 6). Von Graff considers the thick walls of the saccular portion of the œsophagus to be of a glandular nature; this may also be the case in our species, but the columnar cells composing them are certainly very richly ciliated.

The gut proper, or intestine, runs straight from the œsophagus to the anus, which is situated at the posterior extremity of the body (Fig. 12, *a.*) The median portion of the gut lies exactly beneath the proboscis sheath, but it gives rise on either side to a large number of irregular, often branched, saccular or lobate diverticula, which pass outwards and upwards on either side of the proboscis sheath, closely embracing it (Fig. 8).

Just where it joins the œsophagus the gut gives off, as usual, a characteristic diverticulum (Fig. 6, *d. gut*), which runs forward beneath the last portion of the œsophagus and ends blindly.

* *Loc. cit.*

The digestive epithelium has been admirably described by Professor von Graff in the case of *Geonemertes chalicho-phora*, and aptly compared to that of the Planarians. His remarks apply equally well to our species. Only in a condition of rest or hunger are the digestive cells clearly recognisable, when they have the form of elongated, columnar cells, apparently not ciliated. When digestion takes place these cells elongate, put out amœboid processes, seize hold of the food particles and run together into a protoplasmic network which may finally completely obliterate the lumen of the alimentary canal, which then appears to be filled with a granular vacuolated mass of proto-plasm (syncytium). The digested food material is then, apparently, passed out to the surrounding tissues, after which the digestive cells regain their normal condition, or, as seems to me possible, are replaced by new ones.*

Digestion seems to go on chiefly in the lateral diverticula, which generally appear in sections to be more or less filled with a granular syncytium as shown in Fig. 8. In crushed preparations of the living animal this granular material is very obvious in the lateral diverticula and can be easily squeezed out into the central portion of the gut and thence through the anus.

d. The Proboscis Sheath and Proboscis.

The proboscis and its sheath have essentially the same structure as in other Hoplonemertines and a brief description of these parts will therefore suffice. The sheath (Figs. 6, 7, 8, *p. s.*) is a hollow tube running along in the dorsal region of the body above the alimentary canal, and extending from its opening at the anterior extremity to its blind end very near the posterior extremity. It has well-developed muscular walls lined internally by a layer of epithelium. The thickness of the muscular part of the wall, as also that of the epithelial layer, varies much according to the state of distention of the sheath. When the proboscis is completely retracted the walls of the sheath are necessarily much distended and appear relatively thin, while when the proboscis is everted the lumen of the sheath becomes much narrower and its walls much thicker. The muscular portion

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* Compare my account of the digestive epithelium in *Geoplana spenceri* (*loc. cit.*) which was written before I had seen von Graff's remarks on the subject.

of the wall of the proboscis sheath consists of longitudinally and circularly disposed fibres irregularly mixed together, and not arranged in definite layers as seems to be the case in other Hoplonemertines.* Just in front of the anterior attachment of the proboscis, and just behind the mouth, the wall of the rhynchodæum† forms a kind of muscular sphincter, which, when the proboscis is completely withdrawn, closes the entrance. This is not seen in any of the sections figured, but it is very distinctly visible in horizontal sections of a specimen killed with the proboscis retracted.

The cavity of the proboscis sheath, or rhynchocœlom, is filled with a liquid in which float numerous elongatedly spindle-shaped corpuscles, each about 0·09 mm. in length and about 0·0036 mm. in greatest transverse diameter. The two ends of the spindle are very gradually and sharply pointed; the substance of which it is composed stains fairly well with hæmatoxylin, and is scarcely at all granular except in the middle of the cell, where there seems to me to be a nucleus. Von Graff describes similar but smaller bodies in *Geonemertes chalicophora*, but states that they have no nucleus. I can offer no suggestion as to the possible use of these remarkable bodies.

On slitting open the proboscis sheath in an animal which has been killed with the proboscis retracted the latter organ is seen packed aw: y in the sheath in a much bent and crumpled condition. The folding of the proboscis within the sheath appears to be very irregular, and is necessitated by its great length, which far exceeds that of the sheath which has to contain it. If we now gently pull the proboscis away from the sheath (Fig. 13) we shall find that it is attached to the latter at two points, (1) at the anterior extremity, where the muscular walls of the sheath and proboscis become continuous all round (Fig. 6, *m. p.*, Fig. 13, *a. a.*, Figs. 12 and 14, *a.' a'*), and (2) at the posterior extremity of the proboscis, which narrows out to form a long retractor muscle (Figs. 13, 14, *r. m.*) whose end is attached to the inner surface of the wall of the sheath a little in front of the blind end of the latter (Fig. 13, *p. a.*)

The proboscis consists of three main divisions—(1) most anteriorly, the eversible portion (Figs. 14, 15, *e. r.*) which is

* *Vide* von Graff, *loc. cit.*

† The rhynchodæum is the cavity into which the proboscis sheath and alimentary canal both open.

much the largest, (2) the stylet-region (Figs. 14, 15, *st. r.*) and (3) posteriorly, the non-eversible portion (Figs. 14, 15, *n. e. r.*)

The eversible portion is a long, cylindrical tube, attached all round at its anterior end to the proboscis sheath and composed, from without inwards, of the following layers (Fig. 16) :—(1) a delicate epithelium, (2) a very thin layer of circular muscles (*e. c. m.*), (3) a very thick layer of longitudinal muscles (*e. l. m.* and *i. l. m.*), (4) a thickish layer of circular muscles (*i. c. m.*), (5) a sub-epidermic layer ("basement membrane") of hyaline, faintly staining material containing small, scattered nuclei, (6) a layer of glandular epithelium (*gl. p.*) elevated into numerous elongated papillæ which project into the lumen of the retracted proboscis, and into each of which the basement membrane is continued as a more or less distinct core. The longitudinal muscle layer makes up by far the greater part of the thickness of the proboscis wall and is divided into two portions, an outer thinner (*e. l. m.*) and an inner thicker (*i. l. m.*), by the remarkable nerve sheath of the proboscis (*p. n. s.*), which may be conveniently described in this place.

The appearance of the proboscidean nerve sheath in transverse section is shown in Figure 16 (*p.n.s.*) It is composed of a finely granular, faintly staining material (? with a few scattered nuclei) and appears to form a continuous layer. This layer is thickened at frequent and fairly regular intervals to form a circle of stout longitudinal nerves, continued outwards as thin, radiating, vertical plates to the outer circular muscle layer. On their inner aspect the longitudinal nerves are rounded off but occasionally give off small branches towards the inner circular muscle layer. Similar small branches are given off from the portions of the sheath between the longitudinal nerves.

This complicated proboscidean nervous system thus agrees pretty closely with what von Graff has described and figured for *Geonemertes chalicophora.* Hubrecht* has traced this nervous system into connection with the cerebral ganglia, but I have not succeeded in doing this, though I have no doubt that such a connection exists.

The stylet-region of the proboscis is recognisable externally as a distinct swelling at the junction between the eversible and non-eversible portions (Fig. 14, *st. r.*) This swelling is

* *Vide Encyclopædia Britannica*, Article "Nemertines."

divided by a slight transverse constriction into two portions (Fig. 15), an anterior, which seems, as pointed out by von Graff, to belong more properly to the eversible portion of the proboscis, and a posterior, which seems to belong to the non-eversible portion. For the sake of convenience, however, I follow von Graff in considering these two portions together as a separate region of the proboscis, the stylet-region. In longitudinal sections, however (Fig. 15), the two portions of the stylet-region are seen to be even more sharply marked off from one another than appears from the outside.

The structure of the anterior half of the stylet-region is very complicated. If we take a transverse section across it (Fig. 16) we shall see that it is nearly solid. In the centre is a deeply staining, homogeneous mass (Fig. 16, *h.*), circular in outline; this is the so-called "handle" of the stylet, which appears to be of the nature of a secretion. This handle is surrounded by a rather thin layer of radiating muscle (?) fibres, attached to the "handle" at their inner extremities. Outside this layer of radiating fibres comes a rather thin layer of circular fibres, interrupted at one side of the handle by the "poison-duct" (*p. d.*), which contains a granular material. The boundary between the layer of radial muscles and the circular layer is very sharp and distinct and gives one rather the impression of being the wall of a cavity across which the radial fibres run to their insertion in the handle of the stylet. The layer of circular fibres is not very regular, and is seen in longitudinal section (Fig. 15) to be more or less interrupted by radial bands, it is thicker behind the handle of the stylet than around it. Outside this circular layer is a very thick layer of longitudinal fibres interrupted by occasional radial bands. The proboscidean nerve sheath appears to die out in this region of the proboscis, but if I am not mistaken it may be traced as far back as the level of the handle of the stylet (Fig. 16). Outside the thick layer of longitudinal muscles is a layer of large, irregular, highly granular and deeply staining cells (Figs. 15, 16, *gl. z.*). These evidently correspond to the layer of pigment granules described and figured by von Graff in the case of *Geonemertes chalicophora*, but I do not think that in our species they are actually pigmented although their highly granular character gives them a dark appearance under the microscope even in unstained preparations. Lines of granular material radiate inwards from these cells towards the handle of the stylet, and altogether they appear to be of a glandular nature. Possibly, as Bürger suggests,* they secrete the material which forms the handle of the stylet. This layer of glandular, deeply staining cells is interrupted by the sacs which contain the "reserve" or "accessory" stylets. These sacs (Fig. 16, *s. r. s.*) have the appearance of irregular, clear, rounded spaces ; they are not definitely two in number, as appears to be the case in *G. chalicophora*, but their number varies : I have counted as many as five in a single specimen. Nor do they appear to be constant in position, although in the section represented in Fig. 16 two sacs happen to be cut through in a position which seems to have a definite relation to that of the poison canal. Each sac contains about four accessory stylets, whose structure will be considered later on.

Outside the layer of glandular cells is a very thin, uninterrupted layer of longitudinal muscle fibres, followed immediately by a delicate external epithelium, which is extremely difficult to recognise. I could find no trace of an external circular layer of muscles in the stylet-region of the proboscis.

Certain structures in the anterior half of the stylet-region require further notice. These are the stylets, the stylet-handle and the poison canal. All these parts may best be studied in a longitudinal section of the proboscis taken in the plane of the central stylet and poison canal. Such a section is represented in Fig. 15. It will be seen that the stylet-handle is a somewhat pear-shaped structure whose broader end is posterior, while into the narrower end is inserted the base of a stylet, whose apex projects forwards into the lumen of the eversible portion of the proboscis. At one side of the stylet-handle a narrow "poison canal" (*p. cl.*) leads up from the "poison reservoir" (*p. r.*) in the posterior half of the stylet-region. This poison canal leads up to the base of the central stylet The stylets themselves are sharp-pointed, perfectly transparent needles, about 0·12 mm. long and of the shape shown in Fig. 17. Each resembles a nail, with a slightly enlarged head separated from the remainder by a slight constriction. The inner portion appears to be softer than the outer, from which it is pretty sharply marked off, and near the base, or head, is (at any rate in the reserve stylets) a small space, quadrangular in lateral view, which is

* "Untersuchungen über die Anatomie und Histologie der Nemertinen, &c," Zeitsch. für wiss. Zoologie, Vol. 50, p. 1, 1890.

frequently of a black appearance, owing doubtless to the presence of air within it. Sometimes one meets with abnormalities in the development of the stylets. One of these is represented in Fig. 17 (*a. st.*), where several points are attached to one head. Very often small shining globules appear to be attached to the outer surface of the stylet just in the constriction which marks off the head (Fig. 17*a.*)

There can, I think, be little doubt that these calcareous stylets originate, like sponge-spicules, in special mother cells. Occasionally small granular cells (Fig. 17*c.*) may be detected in the sacs containing the reserve stylets, and these sometimes seem to bear already the beginning of a stylet (Fig. 17, *st. m. c.*)

I have not succeeded in finding any communication between the reserve sacs and the lumen of the eversible part of the proboscis, but probably there is some communication as in other species. The structure of the central stylet and the accessory ones appears to be identical, and there can be no doubt that the latter are destined to replace the former when it is broken off or worn away, but the manner in which they come to be inserted into the top of the handle is to me a perfect mystery.

When the proboscis is completely everted the central stylet, of course, must project freely at its free end, and doubtless it forms, with the poison, an efficient weapon of offence or defence.

The posterior half of the stylet-region is less complicated in structure. It is a swollen, bulbous organ, with very thick muscular walls, in which the muscle fibres do not appear to be arranged in definite layers, but circular, longitudinal and oblique or diagonal fibres occur more or less mixed up together in a dense mass. Outside is the usual low epithelium, very difficult to make out, and inside is a large cavity (Fig. 15, *p. r.*), the poison reservoir, which is also lined by a low and apparently non-glandular epithelium, and communicates anteriorly, by means of the poison canal, with the lumen of the eversible portion of the proboscis, and posteriorly, by a short constricted canal, with the lumen of the non-eversible portion. The latter penetrates, with its own muscular coat, for a short distance into the posterior part of the stylet region, as shown in Figure 15.

The non-eversible portion of the proboscis (Figs. 14, 15, *n. e. r.*) is relatively thin-walled, and the muscular elements are not nearly so strongly developed. I have only been able to detect two thin muscular layers, an outer circular and an inner longitudinal. On the outer surface there appears to be as usual a low epithelium, but I have not succeeded in making it out at all clearly. Internally this portion of the proboscis is lined by a highly glandular, very darkly staining epithelium, which I have not been able to clearly differentiate from the darkly staining secretion which fills the lumen. At its posterior extremity the proboscis becomes very narrow and ends blindly. To the blind end is attached a strong bundle of long muscle fibres, the retractor muscle (Figs. 13, 14, *r. m.*), which has its origin on the inner surface of the dorsal wall of the proboscis sheath, a little in front of the blind ending of the latter. When the proboscis is retracted the retractor muscle is short and broad but it is obviously capable of great elongation.

It is, perhaps, hardly necessary to explain the mode of action of the proboscis any further than has been already done. Figure 14, taken from an actual dissection, represents the entire proboscis, with its retractor muscle, separated from the body and in a partially everted condition. It is hoped that reference to this figure will render further description unnecessary. The general view that the protrusion of the proboscis is effected by the powerful contraction of the muscles of the proboscis sheath, acting through the fluid which surrounds the proboscis, while withdrawal is effected by means of the retractor muscle, is doubtless correct. Probably the withdrawal is assisted by the contraction of the muscular diaphragm (Figs. 2–6, *m. d.*), already described, in connection with the anterior attachment of the proboscis to its sheath.

e. Circulatory and Excretory System.

The vascular system is very difficult to make out thoroughly, as, owing to the size and opacity of the body, it must be studied by means of serial sections. There are, as in *Geonemertes chalicophora*, three main longitudinal vessels, one (dorsal or median) lying between the proboscis sheath and alimentary canal, and one (lateral) on either side of the body in the neighbourhood of and ventral to the lateral nerve cords. I have not succeeded in demonstrating any connection between these vessels, unless the network of excretory tubules, to be described presently, be considered as such.

We will first describe the median or dorsal vessel. In the first place it does not keep by any means in the middle line, but is generally found to one side or the other and also curves about considerably. Generally, at any rate in the anterior portion of the body, it appears to keep constantly on one side of the middle line (Figs. 7, 8, *m. v.*)

The diameter of the vessel is by no means uniform. For perhaps the greater part of its length it is a narrow cylindrical tube, but occasionally, and more especially towards the anterior end, it swells out somewhat suddenly into a wide, irregular, lacunar cavity (Fig. 21). The structure of the wall of the vessel is decidedly complex. On the inside, in transverse sections, we see irregularly disposed, deeply staining nuclei (Fig. 22, *nu. v.*), usually projecting more or less into the lumen of the tube. From considerations to be adduced hereafter I doubt whether these are the nuclei of a properly defined epithelium. Outside this nucleated layer there comes a thin layer of very delicate fibres, doubtless muscular, arranged in a circular direction around the vessel (Figs. 22, 23, *c. m. v.*) Outside the muscular layer comes a single layer of large, vesicular-looking, irregularly ovoid, faintly staining cells with small nuclei and slightly granular contents (Figs. 22, 23, *ves. c.*) The wall of the vessel then, in its narrow portions, is made up of three distinct layers. In the swollen, lacunar portions of the vessel (Fig. 21, *l. m. v.*) only the two inner layers can be made out, the outer layer seems to be entirely wanting.

At its extreme anterior end the median vessel becomes narrow again, after swelling out into a series of irregular lacunæ as above described, and passes forward between the œsophagus and proboscis sheath to the level of the ventral commissure (Figs. 6, 18). Here it terminates in a very remarkable manner. A transverse section taken through the region of the ventral commissure will, if taken at exactly the right level, show two curious bodies imbedded in the proboscis sheath, one on each side of the mid-ventral line. These bodies have the form of cellular plugs, containing small, very deeply staining nuclei and frequently projecting very markedly into the cavity of the proboscis sheath. The exact form and position of one of these curious structures will be best understood by reference to Figure 18, representing a small portion of a longitudinal vertical section taken at one side of the median line. It will be seen that in its deeper part, as it passes through the muscular proboscis sheath, the plug (*c. pl.*) forms a relatively narrow stalk, which seems to have a slightly fibrous structure. On reaching the cavity of the proboscis sheath it swells out into a rounded mass of cells, covered, I believe, with a flattened epithelium continuous with the epithelium which lines the proboscis sheath, and projecting into the rhynchocœlom.

The median vessel seems, according to my observations, to be connected with both of these cellular plugs. It appears to be directly continuous with the stalk of the one (Fig. 18) and to send off a branch to the other. Whether there is any constant distinction between the right and the left in this respect I am not able to say.

These cellular plugs appear to me to be probably vestigial structures, and to indicate two things—(1) a former more intimate connection of the median vessel with the proboscis sheath and the rhynchocœlom, such as at the present day exists in many marine Nemertines,* and (2) the former existence of a pair of vessels one on each side of the middle line beneath the proboscis sheath, instead of a single one as at present. Such a pair of vessels exists at the present day in what Oudemans† calls the "Palæo-type." I have been unable to determine whether the right or the left vessel constantly persists in *Geonemertes* or whether it is sometimes one and sometimes the other. Not expecting to meet with any distinction between right and left sides I did not take sufficient care in orientating my section series to justify me in forming a definite conclusion on the point in question. In other words, although the proper sequence of the sections has been rigidly maintained I am not absolutely certain that all the series have been mounted with the same side uppermost. It is some time since many of the sections were cut and I do not like to trust to my memory on such a point.

At its posterior extremity the median vessel is continued into a vessel of smaller diameter, which in histological structure presents a very interesting transition between the main median vessel and the network of excretory tubules to be presently described. A portion of this part of the median vessel is shown in Figure 20. It will be seen that the outer layer of large vesicular cells is absent and that

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* *Vide* Oudemans:—"The Circulatory and Nephridial Apparatus of the Nemertea," *Quarterly Journal of Microscopical Science*, Vol. XXV., Suppl.

† *Loc. cit.*

the whole vessel closely resembles one of the excretory tubules with the addition of a thin layer—apparently discontinuous—of circular fibres around the outside.

The position of the two lateral vessels is shown in Fig. 8 (*l. v*) They are not so distinct and easily recognisable as the median vessel and never seem to attain to such complexity of histological structure. I have not been able to recognise either the circular muscles or the outer coat of vesicular cells in their walls and they seem even more like a specialised portion of the network of tubules to be described presently. Nuclei can be distinguished in their walls and occasionally the vessel dilates into irregular lacunæ (Fig. 23, *l. l. v.*) What happens to the lateral vessels at the anterior and posterior extremities I cannot say, but in the head region there are a number of wide, irregular lacunæ into which they probably open.

In sections which have been stained with Kleinenberg's hæmatoxylin a system of fine, apparently intra-cellular tubules (Figs. 7, 8, *ex. t*) is very distinctly visible, ramifying through all parts of the body between the muscle layers and the proboscis sheath. These tubules run in all directions and branch freely, but they are especially developed in the region of the body above the proboscis sheath and they generally, though by no means always, run in a direction at right angles to the long axis of the body, forming a series of irregular loops curving over the proboscis sheath from side to side. They are also to be found running transversely beneath the alimentary canal. As already stated they branch freely and some of the branches run in the direction of the long axis of the body. These tubules open into the lateral vessels (Fig. 23) and probably also into the median one. I have not been able to demonstrate any opening of the tubules into the latter but they can be traced very close to it and the transitional condition of the median vessel at its posterior end in regard to histological structure is indicative of a close connection between it and the network of tubules. The histological structure of the tubules (Fig. 19) points to an intra-cellular nature. They are very narrow and at fairly regular intervals present very distinct swellings. Each of the swellings is caused by the presence of a nucleus which curves partially round the tubule and which stains very darkly with hæmatoxylin, thus rendering the tubules very conspicuous in sections. Sometimes the tubules appear to be empty and sometimes they appear to be filled with a granular substance. The wall of the tubule between the nuclei is visible as a fine, highly refractive outline.

Although they are such obvious and definite structures in properly stained preparations it is by no means easy to decide upon the true nature of these intra-cellular tubules. The position of the main branches and the connection with the lateral vessels suggests that the former are the homologues of the transverse vessels of other Nemertines. Their histological structure and much branched character suggests that they are excretory in function. The excretory system is so intimately connected with the vascular system in other Nemertines that I am inclined to believe that both these suggestions may be correct.

So far as I am aware no excretory system has yet been described in land Nemertines, and it seems not impossible that in *Geonemertes* the same system of vessels is both excretory and circulatory. Apparently the longitudinal vessels are merely specialised portions of the network of tubules, being similar tubes with the addition in some places of fine circular fibres and an external layer of vesicular cells. Hence I believe the lumen of the longitudinal vessels to be probably intra-cellular.

The great objection to considering the network of tubules as excretory is the apparent absence of any opening whatever to the exterior. In other Nemertines such as *Polia* the excretory pores are easily visible, and in the genus mentioned I have had no difficulty in finding them in transverse sections. Did such distinct openings to the exterior exist in *Geonemertes* I hardly think that I could have overlooked them. It is, however, very possible that smaller openings exist which I have either overlooked entirely or failed to distinguish from the numerous genital apertures to be described presently.

For a long time, also, I could detect nothing of the nature of flame-cells in *Geonemertes*, which one would certainly expect to find in connection with such a system of excretory tubules as I have described. Had I relied solely on my sections I should probably never have found flame-cells at all, but in examining a crushed preparation of the living worm I was fortunate enough to find a beautiful flame-cell in full activity. This is represented in Figure 26, as it appeared in optical section while alive. It will be seen that at one end of the cell there is a triangular projection of denser and clearer looking protoplasm ; the swollen middle portion of the cell is highly granular, and at the other end is a deep pit or excavation, in the bottom of which the flame-like undulating structure (*fl.*) is inserted.

I was able to observe the movements of the "flame" for a considerable time, until they gradually slackened and then ceased. They were extremely beautiful and characteristic, consisting of a series of undulations passing from base to apex in rapid succession and causing the "flame" to exhibit alternate light and dark bands which travelled rapidly along it and at first sight conveyed the impression of successive bubbles of gas escaping from the end of a tube under water.

Probably the flame is made up of a bundle of long cilia, but I could not satisfy myself on this point, although faint indications of longitudinal striations were visible in it.

This cell, I have no doubt, formed the termination of a branch of the system of intra-cellular tubules described above, but I could not trace this system in the living animal owing to the thickness of the specimen and the opacity of the tissues, and it was only by good luck that I found a flame-cell at all in a crushed preparation. As far as I am aware flame-cells have never hitherto been observed in Nemertines except perhaps in the American fresh water species, *Tetrastemma aquarum dulcium*, described by Silliman.* As far as I can gather from that author's description, flame-cells appear to be present, at any rate there are structures which he calls "Flimmer-läppchen" at the ends of narrow branches of the excretory system, but the description of the excretory system is very meagre and unaccompanied by illustrations. As the excretory system of this species appears to agree more closely with that of our *Geonemertes* than that of any other known Nemertine, I may perhaps be allowed to quote it in this place for the sake of comparison:—"Das Wassergefässsystem dieser Art ist sehr leicht zu verfolgen. . . . . . Es scheinen in der Regel zwei selbständige Längsstämme vorhanden zu sein, die sich unter der Leibeswand reichlich verzweigen, besonders im Kopftheile und auf dem Rüssel. Die Ausmündungsporen liegen auf der ventralen Fläche gegen die Mitte der Körperlänge. Die Bewegung der Flüssigkeit wird von den Flimmerläppchen, die in dem erweiterten Ende der kapillaren Zweige sich finden, erhalten." It seems to me very probable that the "Längsstämme" here mentioned may be homologous with

* Zeitschrift für wissenschaftliche Zoologie, Vol. 41, 1885, p. 70.

the lateral vessels of *Geonemertes*, although I have been able to find no external openings in the latter.

There are so many points connected with the circulatory and excretory system of Nemertines still involved in obscurity, that I may well be excused from attempting to give a complete explanation of the structures described above. I would merely suggest as a possible working hypothesis that in *Geonemertes* the excretory and circulatory systems are even more closely related than usual, being in fact represented by one and the same system of vessels, and that *possibly* there are no external excretory openings.

Figures 19 to 23 illustrate the histological structure of various parts of the vascular and excretory systems as seen in sections, and will, it is hoped, sufficiently justify the statements made above as to the form and structure of these parts. For the convenience of comparison all these figures are drawn to the same scale. Figure 26, as already observed, was drawn from life.

It is obvious that the excretory system of *Geonemertes* differs very strikingly from that of marine forms, and it is especially remarkable that it differs even more from that of its marine allies in the group *Enopla* than from that found in the *Anopla*, for, according to Bürger,* the blood-vessels in the marine *Enopla* form no dilatations nor capillaries, and he could find no connection between the blood-vessels and the excretory organs.

f. Nervous System.

The nervous system does not, so far as I have been able to make out, present any striking peculiarities, and a brief description of it will therefore suffice. At the anterior end of the body, immediately behind the muscular diaphragm already noticed, is situated the brain, or cerebral ganglionic mass (Figs. 2, 3, 4, 5, 7). This consists of the usual four lobes found in Nemertines, two on each side of the extreme anterior end of the proboscis sheath. One of the two lobes of either side is larger than the other and is also more dorsal and more anterior in position; we may call it the dorsal lobe of the ganglion (Figs. 3, 4, 5, 7, *d. g.*) The other, smaller lobe of each side is more posterior and ventral and may be called the ventral lobe of the ganglion (Figs. 2, 3, 4, 5, 7, *v. g.*) The right and left ventral lobes are connected together by a

* *Loc. cit.*

stout commissure which runs beneath the proboscis sheath and above the œsophagus and which we may call the ventral commissure (Fig. 6, *v. c.*) The right and left dorsal lobes are similarly connected by a slenderer commissure—the dorsal commissure (Fig. 6, *d. c.*)—which runs above the proboscis sheath. In this way a complete ring is formed around the proboscis sheath. The two ventral ganglia are continued posteriorly into the lateral nerve cords (Figs. 2, 8, 24, 25, *n. c.*) These lie one on each side of the ventral aspect of the body, within the layer of longitudinal muscles (Fig. 8); they run straight to the posterior end of the body, where they unite together above the intestine just in front of the anus.

Various nerves are, of course, given off from the central nervous system thus constituted, but these I have not attempted to work out in detail and, indeed, to do so would, owing to the minute size of the animal, be a very difficult matter. The most conspicuous of these nerves are those which come off from the antero-ventral aspects of the dorsal lobes of the cerebral ganglia (Figs. 4, 5, *n.*) It will be seen from Figure 4 that a specially large trunk leaves the brain just above the ganglion of the lateral organ, and divides into a number of branches, some of which run antero-dorsally and probably supply the eyes, while another runs straight to the sac on the lateral organ and yet another runs backwards and somewhat ventralwards and divides into two short branches, whereof one runs to the posterior end of the ganglion of the lateral organ and the other to the curious œsophageal organ marked *x.* in the figures.

The histological structure of the central nervous system bears a marked resemblance to that of the same organs in *Geoplana*,* but the small nerve-cells are more abundantly developed and more definitely arranged. In the brain they occur abundantly in the outer portion of each lobe, leaving the interior free from their presence. In the lateral nerve cords the nerve cells are arranged in a very characteristic manner, as already described by von Graff in the case of *Geonemertes chalicophora.* They are aggregated in two bands, one on the ventral aspect of the nerve cord and one on the dorsal aspect, but above the dorsal band of nerve cells there is a narrow band of fibrous tissue. This characteristic arrangement of the nerve cells in the lateral cords is best shown in Figs. 2 and 25, (*n. c.*)

* *Cf.* Dendy, "Anatomy of an Australian Land Planarian," Trans. Royal Soc., Victoria, 1889.

g. The Lateral Organs.

By way of preface to this portion of our subject, I will take the liberty of quoting part of Professor Hubrecht's concise and excellent account of the lateral organs given in his article on Nemertines in the latest edition of the *Encyclopædia Britannica* :—

"This apparatus is usually known under the name of the "lateral organs. To it belong (*a*) superficial grooves or "deeper slits situated on the integument near the tip of the "head, (*b*) nerve lobes in immediate connection with the "nervous tissue of the brain, and (*c*) ciliated ducts penetrat- "ing into the latter and communicating with the former. "Embryology shews that originally these different parts are "separately started, and only ultimately become united into "one. Two lateral outgrowths of the foremost portion of "the œsophagus, afterwards becoming constricted off, as "well as two ingrowths from the epiblast, contribute "towards its formation, at least as far as both Hoplo- and "Schizonemertines are concerned. . . . These posterior "brain-lobes, which in all Schizonemertines are in direct "continuity of tissue with the upper pair of principal lobes, "cease to have this intimate connexion in the *Hoplonemertea*; "and, although still constituted of (1) a ciliated duct, opening "out externally, (2) nervous tissue surrounding it, and "(3) histological elements derived from the œsophageal "outgrowths, they are nevertheless here no longer constantly "situated behind the upper brain lobes and directly "connected with them, but are found sometimes behind, "sometimes beside, and sometimes before the brain-lobes. "Furthermore, they are here severed from the principal "lobes and connected with them by one or more rather thick "strings of nerve-fibres. In some cases, especially when the "lobes lie before the brain, their distance from it, as well as "the length of these nervous connexions, has considerably "increased. . . . With the significance of these parts we "are still insufficiently acquainted. . . . Whether in the "Hoplonemertines, where the blood fluid is often provided "with hæmoglobiniferous disks, the chief functions of the "side organs may not rather be a sensory one must be "further investigated."

This I take to be a fair summary of our knowledge of the lateral organs* up to the present time, and I will now

* For further details as to the marine forms the reader is referred to Bürger's excellent memoir already referred to.

proceed to describe the condition of the parts concerned in *Geonemertes australiensis.*

In the first place the lateral organ of each side lies almost entirely below the brain, as will readily be seen by reference to Figure 4.

On the ventral surface of the head there is a slight transverse groove (Figs. 5, 6, 12, *gr.*) in which lie, one on either side of the mid-ventral line, the openings of two narrow and deep pits—the ciliated ducts* or cephalic pits. Following one of the ducts (Fig. 4, *c. p.*) inwards from the external opening we find that it passes obliquely upwards and backwards and, at the same time, towards the side of the body, so that in Figure 5 it appears cut transversely. When it reaches the level of the anterior surface of the brain the duct runs into the substance of a dense mass of small-celled tissue (Fig. 4, *l. g.*) This is evidently the epiblastic portion of what Hubrecht calls the posterior brain-lobe, but here no longer posterior and also widely separated from the rest of the brain. From its position and relations I propose to call this part the "ganglion of the lateral organ."

The ganglion of the lateral organ is an elongated mass of densely packed, small cells, lying longitudinally beneath the anterior and dorsal lobe of the brain. It is somewhat bent upon itself and narrows posteriorly. Near its hinder end it receives the nerve from the brain already mentioned, which joins it on its dorsal aspect just as it passes through the muscular diaphragm. At its posterior extremity the ganglion of the lateral organ becomes continuous with the curious body marked *x.* in Figs. 3, 4, 5, 7. This body I take to be the œsophageal portion of the lateral organ mentioned by Hubrecht, and as it is clearly distinguishable from the remainder of the lateral organ, I propose to call it the "œsophageal organ." The œsophageal organ is very different in histological structure from the ganglion of the lateral organ. It is composed of much larger, nucleated, granular, very darkly staining cells, closely packed together into a dense mass which runs beneath and behind the ventral lobe of the brain (Fig. 4). Its appearance suggests that it may possibly be glandular, but for the present I fear it must be regarded as an organ of unknown function. Figure 4 shows that it

* I have not been able to detect the cilia in my sections except just by the external opening.

lies in close proximity to the œsophagus in the adult animal, and this position, taken together with its histological structure, leaves little doubt in my mind as to its homology with the portion of the lateral organ derived from the œsophagus in other Nemertines. It receives at its anterior end, as already stated and as shown in Fig. 4, a special nerve from the dorsal lobe of the brain, or, to speak more accurately, a branch of the same nerve which supplies the ganglion of the lateral organ.

We must return now to the consideration of the ciliated duct, or cephalic pit, which we left just as it was entering the ganglion of the lateral organ. At this point it divides into two branches (Fig. 4). One of these branches penetrates through the middle of the ganglion of the lateral organ and thence enters the substance of the œsophageal organ, where it disappears; its course is represented by the dotted red line in Fig. 4.

The other branch of the duct turns outwards and, passing in front of the ganglion of the lateral organ, dilates into a relatively large, hollow, laterally compressed vesicle (Figs. 2, 3, 4, *sac*). The wall of this sac or vesicle is composed of a single layer of large, columnar, nucleated cells, chiefly remarkable for their bright yellow colour. The inner end of each cell, towards the cavity of the sac, shows indications of being cuticularized and forms a slight, obtuse projection. Such a saccular diverticulum of the ciliated duct appears, according to Bürger, to be very characteristic also of the marine *Enopla*. Possibly, as Bürger suggests, it is sensory in function.

h. The Eyes.

Geonemertes australiensis differs from all previously described land Nemertines in the possession of a large and indefinite number of eyes, all the previously described species having either four or six. These eyes, of which there may be as many as thirty or forty in our species, are arranged in two groups (Fig. 12, *e. g.*), one on either side of the opening of the rhynchodæum at the anterior extremity of the body. Each group, containing about twenty eyes of various sizes, may show indications of a division into an anterior and a posterior portion, the eyes in the anterior portion being on the average larger than those in the posterior. Whether this is a constant arrangement or not I cannot say, but it suggests that the numerous eyes of *G. australiensis* may have been derived by sub-division of four eyes, two larger anterior and two smaller posterior, such as we find in *G. chalicophora*. Sometimes the eyes in our species appear more or less elongated and sometimes even dumb-bell shaped, which seems to indicate that they multiply by division.

In its minute structure each eye agrees in the main with the eye of *Drepanophorus rubrostriatus* as figured by Bürger,* but I have not been able to make out so much histological detail as that observer. Each eye (Figs. 11, 11*a*) has the form of a deep cup whose opening is turned towards the surface of the body. The wall of the cup is made up of a layer of elongated columnar rods, the inner ends of which, next to the cavity of the cup, are perfectly clear and transparent, while their outer ends are filled with pigment granules. In *Drepanophorus*, on the other hand, the pigment is stated to lie not in the rods themselves but in pigment cells situated behind them. There is also a layer of nucleated cells behind (outside of) the pigmented ends of the rods in *Geonemertes* (Fig. 11) but this appears merely to form a kind of capsule whose cells are perhaps also more or less pigmented. The cavity of the optic cup is filled with a non-staining material which in transverse sections appears finely and regularly granular (Fig. 11*a*). In front of the opening of the cup lies the optic ganglion (Fig. 11, *op. g.*), from which extremely delicate fibrils run down into the cavity of the cup, doubtless to become connected with the inner ends of the rods, as in *Drepanophorus*. The nuclei of the ganglion cells are very easy to make out but not so their protoplasmic bodies. I have not succeeded in tracing the optic ganglion into connection with the nerves given off from the dorsal lobes of the cerebral ganglion (Fig. 4, *n.*) but doubtless such a connection exists as in other Nemertines.

The colour of the eye-pigment is black in the living worm and on the addition of dilute hydrochloric acid it turns to a rich reddish brown colour and partially dissolves.

i. Connective Tissue, Glandular Structures, &c.

The connective tissue, which fills all the interspaces between the various internal organs, agrees very closely with what has been described in other Nemertines. It consists of an almost perfectly hyaline, transparent, non-

* *Loc. cit.* Plate VI. Fig. III.

staining ground substance, resembling closely the ground substance of the mesoderm in Cœlenterata, in which various kinds of cells are imbedded. The most characteristic of the imbedded cells are small, irregularly shaped, finely granular, nucleated masses of protoplasm (Fig. 24, *gr. c.*) which either occur singly or in irregular groups resembling syncytia. These cells are very abundant above and at the sides of the proboscis sheath and also below the alimentary canal, their appearance suggests that they may be amœboid but this of course requires proof.

We also find numerous cells greatly elongated so as to form delicate fibres, but with the nucleus still clearly visible in the middle. These are readily distinguishable in the region between the proboscis sheath and alimentary canal, where the gelatinous-looking ground substance is very strongly developed and contains comparatively few cells. Frequently these cells branch, and I believe they form networks like the stellate mesodermal cells of sponges, which they closely resemble.

Occasionally the gelatinous-looking ground substance appears to be replaced by a close network of very delicate, non-nucleated, transparent fibrils, but this I am inclined to regard as a post-mortem condition due to the method of preparation.

We may mention in this place certain structures which occur imbedded in the ground-substance and which we have not yet had occasion to refer to.

(1) *The Cephalic Gland* (Fig. 7, *c. gl.*).—This consists of a curious mass situated in the head region dorsally and laterally, overlying the proboscis sheath and dorsal lobes of the ganglia, inside the layer of longitudinal muscles. It consists of a number of large, irregular, granular masses, closely packed together. Each mass appears to be made up of a large number of small cells, for each contains numerous small nuclei and sometimes cell divisions can be clearly distinguished. The cephalic gland stains deeply with hæmatoxylin but only slightly (except the small nuclei) with borax carmine and acid alcohol. I have not been able to make out any definite ducts leading to the exterior, but the appearance of my sections leads me to believe that the secretion is passed out through extemporised channels over the back and sides of the head.

Gulliver describes* and figures a "cephalic glandular

* Philosophical Transactions of the Royal Society of London, Vol. 168, 1879, p. 557, *et seq*, Plate LV.

mass" in *Tetrastemma rodericanum*, which apparently closely resembles that of *Geonemertes australiensis*, while a similar gland appears, according to Bürger, to be frequently met with in marine Nemertines.

(2) *Dorsal Glands* (Fig. 6, *d. gl.*)—These consist of very numerous small cells arranged typically in pear-shaped clusters beneath the layer of longitudinal muscles on the dorsal surface, the narrow end of each cluster or bunch of cells pointing outwards. These cells are most abundantly developed in the anterior portion of the body, just behind the head, and are met with only occasionally and in small groups towards the posterior end. The individual cells are characterised by staining very deeply with borax carmine. Each has the form of a somewhat egg-shaped sac with the narrow end pointing outwards. In my preparations the granular cell-contents appear frequently to have shrunk down into the bottom or broad end of the sac, where also the nucleus is situated. In hæmatoxylin preparations the sacs often appear almost empty save for a darkly staining mass lying in the bottom and looking like a local thickening of the sac wall.

(3) *Calcareous Bodies.*—These are clearly visible under the microscope in crushed preparations of the living worm but, curiously enough, I have altogether failed to identify them in my stained sections. They lie beneath the integument and between the lobes of the alimentary canal. They are oval, often irregular, colourless bodies, about 0·028 mm. in diameter and somewhat resembling starch grains in appearance. They do not, however, stain blue with iodine. Under the action of caustic potash they do not swell perceptibly but become very distinct and exhibit a differentiation into an outer wall and a more or less granular contents. Osmic acid does not stain them and alcohol does not dissolve them, at any rate in a short time. They appeared to be unaffected by weak hydrochloric acid so long as I had them under continued observation, but a preparation after prolonged treatment with pretty strong hydrochloric acid (perhaps 15 minutes) no longer shewed them.

From these results I conclude that the bodies in question probably consist of an organic basis more or less impregnated with carbonate of lime.

Von Graff describes somewhat similar bodies in *Geonemertes chalicophora*. They appear to be of about the same size but are flat, and occur in the skin, where they seem to take the place of the rod-like bodies of other forms. Von Graff states that they are mainly composed of carbonate of lime.

I have found no rod-like bodies in *Geonemertes australiensis.*

k. Reproductive Organs.

Bürger* commits himself to the generalisation that terrestrial Nemertines are hermaphrodite, which is somewhat remarkable inasmuch as of the four hitherto described forms two, viz. *Tetrastemma agricola* and *T. rodericanum*, are distinctly stated to have the sexes distinct. In *Geonemertes australiensis* also we find distinct males and females.

Females would appear to be much commoner than males, for I have only found one of the latter amongst the considerable number which I have examined microscopically. The single male observed, although sexually mature, was considerably below the average size ; but females of equally small size also occur, so that it is impossible to found any generalisation as to difference in size of the sexes upon this fact. I have detected no other difference between the two sexes except in the reproductive organs themselves.

In the female (Fig. 24) we find ova in various stages of development irregularly and thickly scattered along the sides of the body, above the lateral nerve cords and beneath the muscular layers of the body wall. Their arrangement appears to bear no definite relation to that of the diverticula of the alimentary canal, which is also irregular.

The ova, from a very early stage in their development, are enclosed separately in special capsules (Fig. 24, *c. ov.*), which open to the exterior along the sides of the body by means of narrow ducts (Fig. 24, *sp. d.*) which pierce the different layers of the body wall. The wall of the duct is merely a continuation of the capsule, and around its point of union with the latter there is a large, placenta-like thickening, as shown in the figure. This thickened portion of the capsule is composed of a mass of small, granular, nucleated cells, whose boundaries are extremely difficult to recognise. Probably the cells of the capsule, and especially those of the thickened portion, aid in the nutrition of the growing ovum,

* *Op. cit.*, p. 260.

which attains a very large size before reaching maturity. The most remarkable fact about the capsule is that in life, as seen on examining crushed preparations, it has a very distinct green colour, strongly suggestive of the presence of chlorophyll. The ovum itself is colourless, but is seen to be surrounded by a capsule composed of numerous small, yellowish-green, granular masses. This I carefully observed in two living specimens from different localities. Whether or not chlorophyll is really present I am unable at present to say, but judging from the analogy of *Convoluta* it seems not altogether impossible. A very tempting field for speculation is thus opened, but until we know whether the green colouring matter is really chlorophyll or some other substance it is perhaps best to keep silence.

The ova, as already stated, grow to a very large size, measuring up to about 0·6 mm. in diameter. It seems to me almost impossible that they should be discharged through the narrow, preformed genital ducts. I believe that they escape by rupture of the body wall and that the ducts merely serve to convey spermatozoa to them. That these ducts do so convey the spermatozoa I conclude from the fact that I have found spermatozoa in them. Probably the process of fertilization is effected by the male crawling over the female and passing out the sperm as he crawls.

The reproductive organs of the male (Fig. 25) are found in the same position as those of the female, namely along the sides of the body above the lateral nerve cords. They also bear, at any rate when mature, a striking resemblance to those of the female in structure. In the earlier stages of their development, however, I have only been able to find irregular masses of sperm-mother-cells in various stages of division (Fig. 25, *sp. m. c.*), without, so far as I could see, any distinct capsule or genital duct. Later on, however, we find densely packed, rounded masses of spermatozoa (Fig. 25, *te.*) each enclosed in a very delicate capsule, which opens to the exterior through a slender duct (Fig 25, *v. d.*) exactly as in the female. After the spermatozoa have been discharged the capsule is still recognisable as a shrunken bag (Fig. 25, *te. ca.*) in whose thin wall nuclei are distinctly visible, and this bag appears simply as a large dilatation on the inner end of the genital duct. The testes are, like the ovaries, extremely numerous, and occur thickly scattered along the sides of the body. As to the origin of the ova and spermatozoa I have no definite observations to record, and can only suggest that they are developed from the granular mesodermal cells (Fig. 24, *gr. c.*) which are very abundant in the neighbourhood of the reproductive organs.

5. Summary.

On comparing the foregoing account of the minute anatomy of *Geonemertes australiensis* with Bürger's already often quoted researches on the marine Nemertea, and especially the marine *Enopla,* it will be seen that the marine and terrestrial forms agree very closely in structure. The most striking and important difference concerns the excretory system, which, in *Geonemertes,* consists of a system of intra-cellular tubules terminating in flame-cells. The circulatory system, moreover, appears to be merely a specialised portion of the excretory system.

Only four species of land Nemertines have hitherto been described, viz.:—*Geonemertes palaensis,* Semper; *G. chalicophora,* von Graff; *Tetrastemma agricola,* von Willemoes-Suhm, and *T. rodericanum,* Gulliver. From all these *Geonemertes australiensis* differs widely, the most striking difference being, perhaps, the large and indefinite number of eyes.

The principal characteristic features of *Geonemertes australiensis* are as follows:—

Animal about 40 mm. long and 2·5 mm. broad when crawling. Colour chiefly yellow, sometimes with a darker median dorsal band of brown. Eyes numerous, about forty, arranged in two main groups one on each side of the head. Lateral organs well developed, opening on the ventral surface of the head in front of the brain by small round apertures sometimes (? always) placed in a transverse groove. No rod-like bodies in the skin, but irregularly oval, calcareous bodies in the deeper tissues. Mouth opening into the rhynchodæum. Sexes distinct. Cephalic gland well developed, but with no conspicuous external opening. Excretory system consisting of branching intra-cellular tubules, provided with flame-cells and connected with the circulatory system. The remainder of the anatomy closely resembles that of the marine *Enopla.* Found under logs and stones in Australia.

6. Description of Plates.

Geonemertes australiensis.

Plate VII.

Fig. 1.—Living specimen with the proboscis everted. Dorsal surface. Painted from life. × $2\frac{1}{2}$.

Figs. 2–5.—Selected from a series of vertical longitudinal sections through the anterior end (stained with borax carmine.) All from one and the same side of the middle line, Fig. 2 being nearest to the outside and Fig. 5 nearest to middle line, to show the brain, lateral organs, eyes, &c. In Fig. 4, which passes through about the middle of one-half of the brain, that portion of the cephalic pit which is not actually visible in the section is represented by a red dotted line. The muscular diaphragm is shown in all the figures and sufficient of the longitudinal muscle sheath to show its connection with the latter. All drawn under Zeiss A, oc. 2, camera outline.

al. c. Alimentary canal.
c. p. Cephalic pit.
d. g. Dorsal lobe of cerebral ganglion.
e. Eye.
ep. Epidermis.
gr. Groove in which openings of cephalic pits lie.
l. g. Ganglion of lateral organ.
l. m. Layer of longitudinal muscles.
l.′ m.′ Forward continuation of longitudinal muscle layer in front of the muscular diaphragm. (Portion only shown).
m. d. Muscular diaphragm.
m. v. Median vessel.
n. Nerves coming off from cerebral ganglion.
n. c. Lateral nerve cord.
p. s. Proboscis sheath.
sac. Sac of lateral organ.
v. g. Ventral lobe of cerebral ganglion.
x. Œsophageal organ.

Plate VIII.

Fig. 6.—Median longitudinal vertical section through the anterior end, from the same series and drawn to the same scale as Figures 2–5.

b. m. Basement membrane.
c. gl. Cephalic gland.
c. m. Layer of circular muscles.
c. o. Common opening of mouth and proboscis sheath (=opening of rhynchodæum).
d. c. Dorsal commissure of brain.
d. gl. Dorsal glandular organs.
d. gut. Forward diverticulum of the gut, passing beneath the œsophagus.
ep. p.s. Epithelium lining proboscis sheath.
gut. Gut proper.
m. Mouth.
m. p. Ruptured muscular attachment of the proboscis to the anterior end of the proboscis sheath.
œs. 1. First, narrow portion of œsophagus.
œs. 2. Median, dilated portion of œsophagus.
œs. 3. Last, narrow portion of œsophagus.
v. c. Ventral commissure of brain.

(Other lettering as before).

Fig. 7.—Transverse section of a specimen stained with hæmatoxylin, taken just behind the cerebral commissures, to show especially the cephalic gland. Drawn under Zeiss A, oc. 3, camera outline. The proboscis being everted the non-eversible portion is seen in section inside the proboscis sheath.

ex. t. Excretory tubules.
p. Proboscis.

(Other lettering as before).

Fig. 8.—Transverse section near the middle of the body. From the same series as Fig. 7. The inequality in thickness of the proboscis sheath is due to irregular contraction. The ovaries happen to be very small in this section. Drawn under Zeiss A, oc. 2, camera outline.

l. v. Lateral vessel.
ov. Ovary.

(Other lettering as before).

FIG. 9.—Small portion of a longitudinal vertical section through the skin and muscle-layers in the ventral region of the body (borax carmine). Drawn under Zeiss F, oc. 2.

gl. c. Sub-epidermic gland-cells.

nu. Nuclei scattered about between the inner ends of the epidermic cells.

o. m. Layer of oblique or diagonal muscle fibres.

(Other lettering as before).

FIG. 10.—Small portion of a tangential longitudinal section passing on the left through the layer of longitudinal muscles, in the middle through the layer of oblique (diagonal) muscles, and on the right through the layer of circular muscles. Drawn under Zeiss D, oc. 2.

(Lettering as before).

FIG. 11.—Longitudinal section of an eye and optic ganglion. From a specimen stained with borax carmine. Drawn under Zeiss F, oc. 2.

op. g. Optic ganglion.

FIG. 11A.—Transverse section of an eye, from a specimen stained with borax carmine. Drawn under Zeiss F, oc. 2.

Plate IX.

FIG. 12.—Ventral view of a specimen from Walhalla preserved in spirit, with the proboscis everted and torn away from its anterior attachment. × 3.

a. Anus.

a.′ a.′ Line along which the proboscis has been torn away from its anterior attachment.

e. g. Group of eyes.

(Other lettering as before).

FIG. 13.—Specimen with the proboscis retracted, dissected from the dorsal surface by slitting open the proboscis sheath longitudinally and pulling the contained proboscis to one side. × 3½.

a. a. Anterior attachment of proboscis to proboscis sheath (compare Fig. 6, *m. p.*)

p. a. Posterior attachment of proboscis (by its retractor muscle), to the proboscis sheath.

r. m. Retractor muscle of proboscis.

FIG. 14.—A semi-everted proboscis detached from the proboscis sheath and with the everted portion slit open to show the non-everted portion lying within.

e. r. Eversible region of the proboscis.
st. r. Stylet-region.
n. e. r. Non-eversible region.

(Other lettering as before).

FIG. 15.—Longitudinal section through the stylet-region of the proboscis. Drawn under Zeiss A, oc. 3.

c. st. Central stylet.
gl. p. Glandular papillæ of the eversible region.
gl. z. Zone of glandular cells.
h. "Handle" in which the central stylet is fixed.
p. d. Poison duct, leading up to the base of the central stylet.
p. r. Poison reservoir in the posterior half of the stylet-region.

(Other lettering as before).

FIG. 16.—Transverse section through a partially everted proboscis. The section passes through the "handle" of the stylet, which is seen in the middle, and the outer portion of the section shows the eversible portion of the proboscis turned inside out and surrounding the stylet-region. Drawn under Zeiss A, oc. 3, camera outline.

e. c. m. External circular muscles of the everted portion of the proboscis.
e. l. m. External longitudinal muscles of the same.
i. c. m. Internal circular muscles of same.
i. l. m. Internal longitudinal muscles of same.
p. n. s. Proboscidean nerve sheath.
s. r. s. Sac containing reserve stylets.

(Other lettering as before).

FIG. 17.—A sac containing reserve stylets, from an unstained preparation. Drawn under Zeiss D, oc. 2, camera outline.

a. st. Abnormal stylet.
st. m. c. Stylet mother cell with commencing stylet.

FIG. 17*a*.—A single stylet, drawn under the same conditions.

FIG. 17*b*.—Head of a stylet, seen end on, drawn under the same conditions.

FIG. 17*c*.—Probable mother cell of a stylet, from one of the reserve sacs, drawn under the same conditions.

FIG. 18.—Small portion of a section from the same series as Figs. 2–6, taken a little to one side of the middle line, between the sections represented in Figs. 5 and 6; to shew the curious cellular plug in connection with the median vessel and projecting into the cavity of the proboscis sheath. Drawn under Zeiss D, oc. 2, camera outline.

c. pl. Cellular plug.

(Other lettering as before).

Plate X.

FIG. 19.—Portion of the system of excretory tubules, from above the proboscis sheath in a transverse section stained with hæmatoxylin. Drawn under Zeiss F, oc. 2.

FIG. 20.—Posterior portion of median vessel, as seen in longitudinal section stained with hæmatoxylin. Zeiss F, oc. 2.

cr. Concretion (?) within the vessel.

FIG. 21.—Portion of median vessel seen in a transverse section stained with hæmatoxylin, shewing one of the lacunar dilatations. Zeiss F, oc. 2.

c.m.v. Circular muscle fibres around the vessel.

l.m.v. Lacunar dilatation of the vessel.

nu. v. Nuclei of the inner wall of the vessel.

ves. c. Vesicular cells outside the vessel.

FIG. 22.—Transverse section of the median vessel. Zeiss F, oc. 2.

(Lettering as before).

FIG. 23.—A lacuna on the lateral vessel with an excretory tubule opening into it. From a transverse section stained with hæmatoxylin. Zeiss F, oc. 2.

l. l. v. Lacuna on the lateral vessel.

(Other lettering as before).

FIG. 24.—Portion of a transverse section of a female specimen, stained with borax carmine, to shew the reproductive organs. Zeiss D, oc. 2, camera outline.

c. ov. Capsule of ovum.

f. g. o. Female genital opening.

gr. c. Granular nucleated cells lying in the gelatinous ground substance.

n. ov. Nucleus of ovum.

s ep. Sub-epidermic glandular layer.

sp. d. Duct through which the spermatozoa reach the ovum.

(Other lettering as before).

FIG. 25.—Portion of a transverse section of a male specimen, stained with borax carmine, to show the reproductive organs. Zeiss D, oc. 2, camera.

m. g. o. Male genital opening.

sp. m. c. Mass of developing sperm-mother-cells.

te. Testis full of spermatozoa.

te. ca. Shrunken capsule of a testis from which the spermatozoa have apparently escaped.

v. d. Vas deferens.

(Other lettering as before).

FIG. 26.—Flame cell. Drawn from crushed preparation of living specimen under Zeiss F, oc. 2.

fl. The flame-like, vibratile bunch of cilia, with alternate light and dark bands caused by its undulatory movement.