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A STUDY OF *STENOSTOMA LEUCOPS* O. SCHM.¹

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THE following paper has been limited to the study of the anatomy, and, as far as possible, the physiology, of a single form, in the belief that in this line our knowledge of this difficult group must, for the present, advance, and that extended comparisons of organs are still premature.

Stenostoma leucops has been selected as a simple and perhaps central form, easily obtainable in abundance at all seasons of the year.

Of special papers on *Stenostoma* and on the family Microstomidæ there are known to me only those of Landsberg ('87*a* and '87*b*), of Zacharias ('85), of Wagner ('89), and of Max Schultze ('49).

Stenostoma leucops is abundant on plants in quiet water, such as is found in small lakes and mill-ponds. It is more likely to be found on chara than on other plants. The worm may be easily obtained at any time during the summer and autumn months by gathering a mass of these plants and allowing them to stand in a glass vessel. The worms soon appear at the surface of the water and on the sides of the vessel. My material comes from a mill-pond of the Huron River, northwest of Ann Arbor, and also from some small lakes three miles west of the city. I experienced no trouble in keeping a supply of these worms all winter in the covered glass vessels in the laboratory.

¹ Work from the Morphological Laboratory of the University of Michigan, under the supervision of J. E. Reighard, was accepted as a thesis for the degree of Master of Philosophy.

METHODS OF WORK.

In studying the living worm, it was found to be of great advantage to slightly compress it under a cover-glass supported by wax feet. *Intravital* stains were found to be of great value in marking out different histological elements of the living worm. Bismarck brown stains the rods in the integument, and them only. Methylin blue stains the pharyngeal cells, and dahlia stains the brain. Details as to methods of using the stains will be given under the organs referred to.

Macerations were found to be a great help in many cases. I obtained the best results by fixing the worms in 1 per cent osmic acid for four minutes and then leaving them in 1 per cent acetic acid for forty-eight hours. They were then placed in a solution consisting of one part glycerine and one part Beal's carmine for twelve hours. When a worm was placed under a cover-glass in this solution, and the cover-glass slightly tapped, the histological elements separated very easily and the nuclei were found to be well stained.

For sections, worms were fixed in both hot and cold corrosive sublimate, chrom-osmic-acetic acid, 1 per cent osmic acid, 33 per cent formic acid, and Perenyi's fluid. Of these fixing agents chrom-osmic-acetic acid was the most satisfactory. It killed the worms before they were distorted, and before any of their parts were in any way broken up.

For staining, alum carmine, hæmatoxylin, and gold chloride gave the most satisfactory results. Kölliker's ('90) silver nitrate method was used with excellent results as a nerve fibre stain.

ANATOMY AND HISTOLOGY.

Integument.

My observations on the structure and arrangement of the different elements of the integument agree with those of earlier observers,—except as to the arrangement of the circular and longitudinal muscle fibres.

Graff ('82, p. 65) says that the circular fibres of the muscular layer of all Rhabdocœls lie next to the epithelial cells, except in *Microstoma lineare*, where the longitudinal fibres lie next to the

epithelial cells. He also states ('82, p. 259) that the integument of *Stenostoma leucops* is constructed like that of *Microstoma lineare*.

Any well preserved section clearly shows that the circular muscle fibres of the integument of *Stenostoma leucops* lie next to the epithelial cells (Fig. 2).

Karyokinetic figures were observed in the epithelial cells. The axes of the spindles are generally parallel to the surface of the integument (Fig. 2).

Parenchyme.

The parenchyme of *Stenostoma leucops* occupies all of the body cavity which is not occupied by the alimentary canal, the water vascular and nervous systems, and the sense organs. It completely surrounds and supports these organs, adapting itself to their shape.

On account of the large alimentary canal, the parenchyme is developed to a very small extent. In the living worm it may be seen in optical section as a light gray, almost transparent mass, surrounding the brain and pharynx, in a narrow strip along the sides of the intestine, and in the triangular area between the posterior end of the intestine and the posterior end of the body.

When the living worm is examined it may be seen to throw the body wall out into a series of wave-like folds along the intestine, thus making a large—in optical section, triangular—space between the integument and the intestine. When this takes place fine, clear, protoplasmic strands may be seen running through this triangular space from the intestine to the integument. It could not be determined in the living worm whether or not these strands unite with one another. There is also to be seen a finely granular fluid mass filling the whole space between the strands.

At the same time that this space between the intestine and the integument is being formed by the throwing out of the fold of the integument, this finely granular fluid may be seen to flow from the surrounding parenchyme into the space and fill it.

When a worm whose integument has been ruptured moves through the water under a cover-glass, it leaves behind it a train

of clear, refractive, protoplasmic parenchyme. If the worm remains quiet, the parenchyme is not seen to flow out.

In sections, the appearance of the parenchyme varies according to the method of fixation. In sections from a worm which has been fixed with corrosive sublimate (Fig. 3), the parenchyme may be said to be made up of a large number of irregularly distributed, amœboid cells, and a finely granular plasm filling the spaces between the cells. In many places the cells may be seen to be closely massed together. The finely granular plasm (*Pro.*) takes a light purple stain with hæmatoxylin. In many cases the processes of the cells may be seen to connect them with one another (Fig. 3). The cells vary much in size. The largest of them are $4\ \mu$, while the smallest are $1.5\ \mu$ in diameter. They are finely granular and are provided with round or oval, coarsely granular nuclei (*N.*), which become deeply stained in hæmatoxylin. The nuclei of the largest cells are $1.5\ \mu$, while those of the smallest cells are but $.3\ \mu$ in diameter. No nucleoli were seen.

In sections of worms which have been fixed in chrom-osmic-acetic acid (Fig. 4) the parenchyme may be seen to be made up of an irregular network (*X*) of darkly stained, finely granular material. In some places the network appears broken. The spaces included within this network vary greatly in size and shape. Some of them are not more than $1\ \mu$ in diameter, while others have a diameter of $5\ \mu$. These spaces are filled with a finely granular plasmic material, which with the hæmatoxylin did not become as deeply stained as the network. In some spaces the plasm takes a dark purple stain while in others it takes a very light purple stain. The network surrounding the dark spaces is not as broad and prominent as that surrounding the lighter spaces. In many of these lighter spaces the dark stain of the network may be seen to merge gradually into the lighter stain of the plasm in the spaces.

In many places circular or oval thickenings of the material composing the network may be seen at the points where the meshes of the network join. Sometimes dots which are like these thickenings in structure are seen within the spaces and free from the network.

A few large amœboid cells (*Ce.*) may be seen irregularly scattered through the parenchyme and connected by their processes

with the network. These cells vary much in size, ranging from 2μ to 4μ in diameter. They are finely granular and take a dark stain with hæmatoxylin. They have large round or oval nuclei which range from 1μ to 2.5μ in diameter. These nuclei are stained much darker than the cells. In the nuclei of some of the cells may be seen eccentrically situated very dark nucleoli $.5\mu$ in diameter.

Graff ('82, p. 68) divides the parenchyme of Rhabdocœls into—I, "sagittal Muskel-fasern"; II, "Bindegewebsbalken"; III, "Bindegewebszellen." He describes the "sagittal Muskel-fasern" as long, strong fibres of uniform width and of a smooth shining appearance, which are present in only a few Rhabdocœls (*Mesostoma*, *Vortex*, and *Proboscida*). They run through the parenchyme from one part of the integument to another. In *Mesostoma* some fibres run from the alimentary canal to the integument. The "Bindegewebsbalken" are the meshes of a finely granular network which run in an infinite number of planes. Sometimes these meshes broaden out into broad plates and sometimes they are but delicate fibres. These meshes are not stained with carmine or hæmatoxylin. As a rule, numerous nuclei may be seen in the meshes. In the meshes of *Microstoma lineare*, however, no nuclei are visible. The "Bindegewebszellen" are amœboid cells which are scattered among the meshes of the network and lie free in the perivisceral fluid which, together with the amœboid cells, fills the spaces in the network.

Böhmig ('90, pp. 197–206) discusses the parenchyme of Turbellarians in general. He says that the parenchyme of the forms in this group is made up of two distinct substances: a Gerüst-substanz," which is arranged in a network, and which encloses spaces or chambers of very different size and shape; and a very finely granular "Saftplasma" or "Hyaloplasma," which fills the chambers of the network. He ('90, p. 200) says that these spaces in the network are not entirely separate from one another, and that the "Saftplasma" contained in them forms a continuous mass throughout the whole body. Summing up, he ('90, p. 205) says, "Das Parenchyme der Turbellarien besteht ursprünglich aus individualisirten Zellen." He also states that the manner in which these cells are modified to form the network is different in different forms. In the Alloiocœls and a part of the

Rhabdocœls each cell of the parenchyme is made up of a Gerüstsubstanz and a Saftplasma. The Gerüstsubstanz forms the periphery of the cell and is also arranged in a network throughout the cell. The Saftplasma fills the spaces bounded by the network within the cell. The peripheral layers of Gerüstsubstanz of the single cells come to be interrupted, thus destroying the cell boundaries, allowing the Saftplasma of adjacent cells to mingle, and making the general network of the parenchyme. "Das Gerüst Werk des Parenchyme ist die Summe der Zellgerüste."

In both groups of the Dendrocœls and probably in some Rhabdocœls vacuoles are formed in the developing parenchyme. These vacuoles are inter-cellular in the Triclad and intra-cellular in the Polyclads. Thus in the Polyclads the network which partly surrounds each vacuole is made up of the periphery of the cell in which the vacuole was formed. In the Triclad each vacuole is surrounded by a network which is composed of the whole of the originally adjoining cells.

In conclusion, Böhmig ('90, p. 206) says, "Die Trennung des Parenchymgewebes in Bindegewebsbalken und Bindegewebszellen (V. Graff) muss aufgegeben werden, wie auch Iijima für die Tricladen und Lang für Polycladen betont hat."

From the study of both the living *Stenostoma leucops* and from sections (pp. 265-267) the parenchyme is seen to be made up of two substances,—a network (Böhmig's "Gerüstsubstanz"), and a perivisceral fluid (Böhmig's "Saftplasma").

The spaces enclosed within the network are connected with one another by the openings through the network, and the perivisceral fluid is a continuous mass throughout the parenchyme, as may be seen in sections and in the living worm. In sections a break in the network is occasionally seen, so that the contents of adjacent spaces are continuous. In the living worm the perivisceral fluid which is contained in the spaces of the network could not flow from one part of the parenchyme to another (p. 265) unless there were continuous passage-ways from one space to another.

In the parenchyme of worms which have been fixed with corrosive sublimate the cells may be seen in many places to be massed together, while in other places they are separated a short distance and are connected by their processes into a net-

work. In the parenchyme of worms which have been fixed in chrom-osmic-acetic acid large cells may be seen connected with the network. This network resembles the cells very much, both as to the fineness of its granules and as to the amount of stain that it takes.

The above facts indicate that, as Böhmig states for Triclad and as he surmises for some Rhabdocoels, the network of the parenchyme of *Stenostoma leucops* is formed by the fusion of individual cells, which are connected by longer or shorter branching and anastomosing processes (Gerüstsubstanz) and are separated by inter-cellular vacuoles.

Alimentary Canal.

The alimentary canal of *Stenostoma leucops* occupies the posterior three-fourths of the body cavity of a single individual. In some cases the posterior part of the alimentary canal (intestine) as seen in the living worm is in contact laterally with the integument, while in others there is a slight space (parenchyme) left between it and the integument. In the majority of cases the intestine does not reach to the posterior end of the body, so that there is, in the living worm in optical section, a clear triangular space left between the posterior end of the alimentary canal and the posterior body wall.

In other cases the posterior end of the intestine is in contact with, or a very slight distance from, the posterior body wall. These differences in the relation of the alimentary canal to the body are due to the state of contraction of the animal, to its stage of development, and also to the degree of distension of the alimentary canal.

In an individual from which a bud has recently separated the alimentary canal reaches to the posterior end of the body. Before this separation takes place the lumen of the intestine is obliterated by a constriction between the bud and the mother, and the opening leading to the bud is thus closed. The bud separates from the mother before a similar constriction of the integument has travelled far enough to entirely close the ends of the divided body wall tube. It thus happens that for a time the posterior end of the intestine of the mother is left exposed. After the bud has become free the posterior body wall of the

mother closes up and fits closely against the posterior wall of the alimentary canal, thus leaving the posterior end of the body bluntly rounded. This posterior body wall gradually grows backward and becomes sharper until, in a quiescent worm, the posterior end of the body is separated from the posterior end of the alimentary canal by a space equal to the greatest width of the body.

That part of the alimentary canal posterior to the mouth is a straight tube occupying the centre of the body as seen in cross-section. In the living worm it varies in color from a light green to a brown. This coloring is more marked in the intestine, where the greater part of the color is due to the fact that the food particles enclosed within the intestine can be seen through the body tissues.

There is but one opening to the alimentary canal, the mouth opening (Fig. 1, *M*). This opening is at the bottom of a cone-shaped depression of the integument (Fig. 5, *C.D.*) which is located on the ventral side of the body. When the animal is at rest, the distance between this depression and the anterior end of the body is about equal to the greatest width of the body. This depression is very variable in its form. Sometimes it is very long and slender, as in Fig. 5, and sometimes it is short and thick.

It is lined with ciliated epithelial cells similar to those of the body wall, except that they are smaller. The muscular wall is very thin and is made up of circular and longitudinal muscle fibres. The circular fibres like those of the integument are next to the epithelial cells.

The alimentary canal has a distinct muscular wall by means of which it moves independently of the movements of the body, although this wall is not as contractile as the body wall.

The alimentary canal is divided into two parts; viz. pharynx and intestine.

Pharynx. — The pharynx, as seen in the living animal in a quiescent state, is cask-shaped, being as long as the greatest diameter of the body, and one-half as wide (Fig. 1, *Ph.*). Its anterior end opens through the mouth to the outside, and its posterior end opens into the intestine.

The wall of the pharynx is made up of an outer muscular layer and an inner layer of ciliated cells.

The muscular wall is made up of longitudinal and circular fibres which run at right angles to each other. The longitudinal fibres are next to the ciliated cells. In a cross-section the longitudinal fibres (Fig. 6, *L.M.*) are oval, their greatest diameter being perpendicular to a radius of the pharynx drawn to them. These fibres are $.75\ \mu$ broad and $.5\ \mu$ thick.

The circular fibres (Figs. 7 and 8, *C.M.*) are also oval in cross-section and somewhat larger than the longitudinal fibres. They are $1\ \mu$ in breadth and $.5\ \mu$ in thickness. Their greatest diameter is parallel to a radius of the pharynx drawn to them. The circular fibres are more plentiful than the longitudinal. The longitudinal fibres, when the pharynx is in its normal shape, are separated from one another by an interval equal to double their own width, while the circular fibres are not further apart than the length of their smallest diameter. No nuclei were discovered in these fibres.

The inner layer of ciliated cells is made up of a single tier of cells. These cells (Fig. 6) are club-shaped, with their narrow ends attached to the muscular layer. They range from $3\ \mu$ to $3.5\ \mu$ in length, and are $1\ \mu$ in width. From their large distal ends extremely long and slender cilia (*C.*) project into the lumen of the pharynx and nearly fill it. The cilia are from $7\ \mu$ to $9\ \mu$ in length,—nearly three times as long as the cells which bear them.

There is a distinct line of demarcation between the anterior end of the pharynx and the cone-shaped depression of the integument. This is noticeable both in the ciliated cells and the muscular layer. As was before stated, the ciliated cells lining the depression are like those of the integument. These cells grow gradually smaller from the outside toward the pharynx. At the point *x* (Fig. 5) they cease to be visible, and immediately beyond that point the very much larger pharyngeal cells, which are provided with much longer cilia, may be seen occupying the same position relative to the muscular wall.

There is also a difference in the relation of the fibres of the muscular layer to the epithelial cells of the two regions. As was stated above, the longitudinal fibres of the pharynx lie next to the epithelial cells, while in the cone-shaped depression the circular muscle fibres occupy that position. The circular and longitudinal fibres of both the pharynx and the depression

become gradually smaller toward the point where occurs the sudden change in the form of the epithelial cells. At this point occurs the transition in the relations of the muscle fibres to the epithelial cells. Thus these changes in both the epithelial cells and the muscular wall coming at the same point mark off the pharynx from the cone-shaped depression.

Surrounding the pharynx and in contact with the muscular wall is a large number of pear-shaped cells (Fig. 6, S.). When a living worm is treated with methylin blue these cells alone are stained, and it may then be seen that they are distributed uniformly over the whole pharyngeal region. In longitudinal sections also they may be seen to be distributed over the whole length of the pharynx. These cells are connected with the wall of the pharynx by their smaller ends. There is a great variation in their size. Some are no larger than the ciliated cells of the pharyngeal wall, while others are so large that they reach nearly to the body wall of the worm. The largest of these cells are $20\ \mu$ long and $4\ \mu$ wide, while the smallest are $3\ \mu$ long and $1\ \mu$ wide. Many of the small cells represented in Fig. 6 are but parts of the larger cells which have been cut in the sectioning.

Many of the largest cells are seen to connect with the pharynx by long stalks which, according to Graff (82, p. 259), run through the pharyngeal wall and open into the lumen. I was not able to trace them through the wall. In a longitudinal section (Fig. 7) I could trace a stalk between two of the outer circular fibres, but could not trace it farther.

These pharyngeal cells lie free in the body cavity with no other attachment than that of their narrow ends at the wall of the pharynx. They are supported by the parenchyme and the numerous muscle fibres which run between them.

They are coarsely granular and have very large ovoid nuclei (Fig. 6, N.) in their large ends. Some of the largest nuclei are $3\ \mu$ long and $2\ \mu$ wide. They take the hæmatoxylin stain freely and become very dark in nearly all cases.

The muscular wall of the pharynx is connected with the muscular wall of the integument by numerous muscle cells. These muscle cells may be divided into two sets. The first set which I shall call *radial muscle cells* radiate from the pharynx to the integument (Fig. 8, R.M.).

The second set (*P.R.M.*) I shall call *pharyngeal retractor muscle cells*, on account of their function of retracting the pharynx.

The *radial muscle cells* are very numerous. Those from the centre of the pharynx run to their attachment at the integument in a direction perpendicular to the long axis of the pharynx. Those from the posterior end are inclined backward, while those from the anterior end are inclined forward. These cells vary much in length and width,—the longest ones being the narrowest. They are from $25\ \mu$ to $50\ \mu$ in length and from $1\ \mu$ to $5\ \mu$ in width. This difference in form is largely due to their state of contraction.

Both ends of these muscle cells are split up into numerous fine thread-like processes which run between the muscle fibres of the pharyngeal and body walls, and thus serve to attach the cells.

The muscle cells are finely granular and have very large coarsely granular ovoid nuclei (Fig. 8, *N.*) located in the centre of the cell. The largest of these nuclei are $5\ \mu$ in length and $3\ \mu$ in width. They have small round eccentrically placed nucleoli (*N'.*) which are $1\ \mu$ in diameter. In the alum-carmines sections from which Fig. 8 was taken the chromatin network of the nuclei was seen.

The *pharyngeal retractor muscle cells* (Fig. 8, *P.R.M.*) are not as numerous as the radial muscle cells. They run from about the middle of the pharynx backward, interweaving with the radial cells, and connect with the body wall opposite the anterior end of the intestine. These cells are like the radial cells in structure. They are provided with coarsely granular nuclei (Fig. 8, *N.*), but I could not make out that their ends were broken up as is the case with the radial cells.

At the opening between the pharynx and intestine the walls of each are so arranged that they form a circular valve. This valve (Fig. 8, *V.*) is formed by the turning in of the anterior end of the wall of the intestine, to form a cup-like depression, at the bottom of which the intestine is joined by the pharynx.

This valve is lined with epithelial cells intermediate in character between those of the pharynx and those of the intestine.

Intestine.—The intestine is the posterior part of the alimentary canal. It fills nearly the whole of the posterior, half of

the body cavity. It is somewhat smaller at its posterior end than at its anterior, and ends as a blunt cone. In the living worm the wall appears to be thrown up into small folds, which give its outer border a wavy appearance in optical section. Besides the green and brown food particles mentioned above, many small spherical oil-globules which are very highly refractive are seen scattered through the intestine.

Stenostoma leucops is one of the few Rhabdocœls in which the intestine has a distinct muscular wall. This wall is not as thick as that of the pharynx. It is made up of circular and longitudinal fibres running at right angles to each other. The longitudinal fibres lie next to the epithelial cells lining the intestine, while the circular fibres lie next to the parenchyme (Figs. 9 and 11). The circular fibres (Fig. 9, *C.M.*) are circular in cross-section. They are $.5\ \mu$ in diameter. The longitudinal fibres (Fig. 11, *L.M.*) are flattened bands nearly $1\ \mu$ in width and $.3\ \mu$ in thickness. Their broadest surface lies next to the circular fibres. The intestine is not connected with the integument by any muscle fibres. It lies free in the body cavity, and is supported only by its attachment to the pharynx, and by the parenchyme surrounding it.

The whole of the interior surface of the intestine is covered with a single layer of large pear-shaped cells which are attached to the muscular wall by their smaller ends, and have their long axes directed radially. They are of nearly equal size over the whole surface except near the valve, where they are somewhat smaller. The average cells are $20\ \mu$ long and $5\ \mu$ wide at their large distal ends. These cells resemble the intestinal cells of all other Rhabdocœls (Graff, '82, p. 92) in being without a cell wall.

The cells are made up of a very tenacious finely granular protoplasm. Their peripheral protoplasm is clearer while their central protoplasm is more coarsely granular and is arranged in a fine network (Fig. 9). The large distal ends of these cells are filled with vacuoles and food particles, among which are the oil-globules mentioned above. The number and size of the vacuoles gradually decrease toward the base of the cell. In sections which have been stained with alum carmine the large vacuoles at the distal ends of the cells may be seen to contain many small round bodies (Fig. 9, *E.*) which have been stained dark red or violet.

At the base of the cell is a large round or ovoid nucleus (Fig. 9, *N.*) $1.5\ \mu$ in diameter. In the nucleus is a small round darkly stained nucleolus (*N*¹) which is centrally located. It is $.5\ \mu$ in diameter.

When a living worm is slightly compressed, motion which resembles very much the movement of cilia, is seen in the intestine. This is best seen in the posterior end, where the intestine is thinnest. In sections (Figs. 9-12, *P.P.*) the distal end of the cell is seen to be covered with long, very narrow protoplasmic processes wider at the base and gradually tapering to a point. In some cases these processes are seen to be run together into a mass (Figs. 9 and 12, *X.*).

These processes project not only from the end of the cell, but also from a short distance down the sides. When the cells are closely packed together, the processes from the sides of the adjoining cells become so closely matted that they many times fuse and have the appearance of large protoplasmic projections from between the cells. These processes vary very much in size. The most of them are $8\ \mu$ to $10\ \mu$ long, but some become as long as the cells themselves.

When the intestinal cells are crushed out of a living worm, they assume a spherical form, with the long processes coming out from one side only (Fig. 10). When first pressed out they move about in the water very rapidly. They soon become comparatively quiet, and then they may be seen to have withdrawn the long narrow processes, and to undergo amoeboid movement by putting out blunt pseudopodia. When the cells are in this condition, fine particles may also be seen moving about in them. One or more oil-globules which remain comparatively quiet may also be seen within the cell. When these cells were treated with .75 per cent salt solution, they became quiet. When the same solution containing methylin blue was applied to them, the nuclei (Fig. 10, *A.* and *B.*, *N.*) of the cells appeared, but no nucleoli could be distinguished.

In sections of worms which had been treated with chrom-osmic-acetic acid, the intestinal cells were filled with spherical oil-globules which had been colored black by the action of the acid. The large majority of these globules are situated at the distal ends of the cells. They vary greatly in size. Generally there is one $4\ \mu$ to $6\ \mu$ in diameter in a cell. This large one is sur-

rounded by many smaller ones $1\ \mu$ to $1.5\ \mu$ in diameter (Fig. 11, *O.*). In some cells the small globules are not present, and the large globules are much larger than in cells where the small ones are present (Fig. 12, *O.*).

When the living worm is studied, it can be seen that when it takes food the anterior end of the pharynx is brought down nearly to a level with the body wall, thus drawing the pharynx out into a long narrow tube. The mouth is also seen to be opened wide. At the same time the wall of the cone-shaped depression is protruded and forms a circular ridge on the body wall bordering a cup-shaped depression at the bottom of which is the mouth opening. When the pharynx is in this position, the worm moves about among the food particles floating in the water. The rapid movement of the cilia, both of the depression and of the pharynx, causes a current of water containing food particles to flow into the mouth opening. This current of food particles is kept moving in at the mouth for some time; then the worm quickly contracts the wall of the pharynx so that it takes the form of a hollow sphere. The circular ridge on the body wall surrounding the mouth opening disappears, having been drawn in by the contraction of the pharynx. At the same time the mouth is closed and the further contraction of the pharynx forces the food through the valve into the intestine. This valve is so arranged that its normal position allows food to pass into the intestine while it does not allow it to pass out.

As soon as the food is in the intestine, the worm seeks more and takes it in the manner described above. While it is taking this food, that which it has already taken remains in the intestine, being held there by the valve.

Occasionally the worm may be seen to contract the integument of the posterior part of the body and at the same time to contract the walls of the intestine. At the same time the whole pharynx is thrown forward and the mouth is brought wide open to the surface of the body. When this is accomplished, a mass of waste material and undigested food is extruded. After this the worm immediately resumes its natural position.

Thus it may be seen that the mouth is not only the place where the food is taken in, but also the opening through which the worm rids itself of refuse matter (Graff, '82, p. 97).

When the worm takes food the mouth may be opened by the

relaxation of the circular muscle fibres of the pharyngeal wall combined with the contraction of the radial muscles which are connected to the anterior end of the pharynx, while the pharynx itself is held in place by the pharyngeal retractor muscles. When waste material is extruded, the whole pharynx may be brought forward, and the mouth and the valve between the pharynx and intestine opened at the same time by the relaxation of the pharyngeal retractor muscles and the contraction of all the radial muscles.

Stenostoma leucops feeds on both animal and vegetable matter. The greater part of its food, however, is vegetable matter. Small algæ are very often seen in the intestine. In the intestine of one specimen I found a *Diffugia* and a small Crustacean which was so broken up that it could not be identified.

The food passes through the mouth and pharynx into the intestine, where it remains until digested or extruded. After milk has been fed to some of these worms for a short time oil-globules may be seen in the lumen of the intestine, and in the intestinal cells. By dropping a drop of the milk into the water it was fed to some worms which had been for some time previously in a watch glass of clean water. The milk did not mix readily with the water. The worms swam to the uniting surface between milk and water and quietly remained there while feeding. Sometimes they darted through the thickest part of the milk. They were left in this for fifty minutes, after which they were put in pure water. When some of these worms were compressed so that the intestinal cells were crushed out, the cells were seen to contain each three or four oil-globules, while scarcely more than one could be seen in the cells of worms of the same lot which had not been so fed. Some of these worms were treated with osmic acid and sectioned. When the sections were studied, the outer ends of the cells were seen to be filled with very small oil-globules.

The three facts,—that the globules just mentioned are so small, that when there is a large globule in the cell the small ones are arranged around it, that when there are no small globules in the cell the large globules are very much larger than the large globules in the cells which contain also the small globules (p. 276)—point to the conclusion, that the oil first appears in the cells in small globules which afterward unite to form the large ones.

For a further proof that the very small oil-globules in the intestinal cells were directly due to the worms feeding upon the milk, a number of worms was divided into two lots. One lot was fed with milk as before, while the other lot was not fed. Both lots were treated with chrom-osmic-acetic acid, stained with alum, carmine, and sectioned. When these sections were compared, the intestinal cells of the worms which had been fed the milk contained many more oil-globules than the cells of the worms which had not been fed. Two cells of a worm which had been fed contained each twenty-two and sixteen oil-globules, while two cells from the same locality of a worm which was not fed contained each ten and nine oil-globules. These worms were in the milk less than an hour.

My observations agree with those of Graber ('79, p. 278) and Graff ('75, p. 414; '82, p. 258) as to the form of the intestinal cells after they have been crushed from a living animal, but do not agree with those of Graff upon the form of the cells as they are seen in their natural condition in sections. In this condition these cells are not cylindrical as described by Graff, but club-shaped, as described by Böhmig ('90, p. 234) for *Plagiostoma* and *Cylindrostoma*.

As to the behavior of the isolated intestinal cells, I am able to confirm the observations of Du Plessis ('74) on *Plagiostoma Lemani*, Metschnikoff ('78, p. 388) on *Mesostoma Ehrenbergii*, Graber ('79, p. 278) on *Stenostoma leucops*, and von Ihering ('80) on *Graffilla muricicola*; and also those of Metschnikoff as to the difference between the size of the cells in a worm which has been recently fed and one that has not been fed.

Böhmig ('90, p. 235) saw in *Plagiostoma Girardi* and *Cylindrostoma Klostermannii* pseudopodia-like protoplasmic processes protruded and retracted, and at times fused into a mass. He says (p. 236): "Es ist bekannt, dass die Darmzellen von *Microstoma*, *Stenostoma*, und *Macrostoma* Cilien tragen. Nicht unwahrscheinlich ist es mir, dass diese Cilien, ich möchte sagen, starr gewordene Plasmafortsätze sind wie wir sie bei den *Alloioecelen* wahrnehmen."

Speaking of the function of the intestinal cells of *Plagiostoma Girardi* and *Cylindrostoma Klostermannii* he says: "Die Funktion dieser plasmatischen Fortsätze ist leicht zu verstehen: sie werden ähnlich wie die Pseudopodien und pseudopodien-

ähnlichen Ausläufer der Amöben zum Umfassen und Aufnehmen der Nahrungsobjekte dienen."

The fact that the so-called cilia (Graff) at the distal ends of the intestinal cells of *Stenostoma leucops* as observed by me are very much thicker than the ordinary cilia, and that in sections they may be seen to have fused, together with the fact that I have seen them in the living cells to have been retracted and replaced by blunt pseudopodia, shows that they are as Böhmig surmises, pseudopodia-like protoplasmic processes rather than true cilia.

I have no direct observations as to the participation of these processes in the taking of food particles, but the facts stated above, together with the fact that the cells which are filled with food particles (milk globules in *Stenostoma leucops* and blood corpuscles in Planarians according to Metschnikoff) are much larger than cells not so filled are usually taken as evidence of such participation.

Graff ('82, p. 259) divides the part of the alimentary canal of *Stenostoma leucops* between the opening at the ventral surface of the body and the anterior end of the intestine into a posterior oesophagus free from pharyngeal cells and an anterior pharynx into which alone the pharyngeal cells open. As this division is based on the openings of the pharyngeal cells only, and as I have shown that these cells in *Stenostoma leucops* open along the entire length of that part of the alimentary canal between the cone-shaped depression and the intestine, this part of the tube according to Graff should be designated as the pharynx.

Graff ('82, p. 88), basing his conclusions on the development of the pharynx of *Stylochopsis* (a Polyclad) as described by Goette ('82) and on his own observations on the formation of the new pharynx in the budding *Microstoma*, believes that the entire pharynx of the Rhabdocoels is to be regarded as a depression of the body wall and therefore lined with ectoderm. He believes that the pharyngeal apparatus is homologous throughout the Tubellaria, although he admits that without a knowledge of its development it is impossible to place this homology on a sound basis.

Hallez ('79) as abstracted by Korschelt and Heider ('90, p. 114) says the pharynx of Rhabdocoels appears to be derived from the entoderm.

Wagner ('89, p. 191; see page 298), in describing the process of budding in *Microstoma*, derives the new pharynx from the parenchyme, and also describes a short depression of the integument leading to it.

I have found that in the budding of *Stenostoma leucops* the new pharynx is formed by a process like that described by Wagner for *Microstoma*. (See page 298.) My observations differ from those of Wagner only in this respect, that I find the cone-shaped depression of the integument more pronounced. I know of no other observations on the development of the pharynx in Rhabdocoels.

Turning to the Polyclads, we find the observations of Goette as quoted above. In addition to these we have those of Lang ('88, p. 166) and Hallez ('79). These observers agree in deriving the entire pharyngeal apparatus from a depression of the ectoderm.

Among the Triclad s we have the observations of Iijima ('84) and Hallez ('87) showing conclusively that the pharynx is derived from the entoderm (mesoderm).

It has been shown by Wagner for *Microstoma* and myself for *Stenostoma* that the simple pharynx of the Microstomidæ consists of two parts. One of these is formed by an ectodermic depression, and to this I have given, tentatively, the name "cone-shaped depression." The other portion is formed from the parenchyme (mesenchyme), and this I have called "pharynx" in the narrower sense.

The cone-shaped depression differs from the pharynx in its mode of development, in the character of its epithelial cells, and in the arrangement of its layers of muscle fibres. I believe it to be homologous with the entire pharyngeal apparatus of the Polyclads.

The portion which I have called the pharynx in *Stenostoma leucops* is derived from the parenchyme in the process of budding, and differs from the cone-shaped depression in the manner stated above.

The parenchyme cells, from which the new pharynx is formed, might be derived by a migration of cells from the adjacent ectoderm. If this could be shown to be the case, the whole pharyngeal apparatus (cone-shaped depression and pharynx) of the Microstomidæ would be shown to be of ectodermic origin,

and therefore equivalent to the pharyngeal apparatus of Polyclads.

Neither in *Microstoma* nor in *Stenostoma* have we any evidence that such a migration actually takes place. In *Microstoma* there is, on the other hand, no reason for denying the possibility of such a migration.

In *Stenostoma* if the cells which form the new pharynx had been derived from the ectoderm, we should expect the pharynx resulting from them to show the same histological character of its lining cells and the same arrangement of the muscle-fibre layers that we see in the general ectoderm and in the cone-shaped depression.

In respect to the character of its epithelial cells the pharynx of *Stenostoma* agrees more nearly with the intestine than it does with the integument. In respect to the second point the muscle-fibre layers of its walls show an arrangement the reverse of that which obtains in the integument and identical with that found in the intestine. It is thus much more in accordance with the facts to regard the parenchyme cells from which the new pharynx is formed as potentially entoderm and to homologize what I have called the pharynx with the pharynx of the Triclad. The parenchyme cells which form the pharynx are probably not derived from the entoderm which lines the adult intestine. It is more likely that they are a part of the original mesenchymatous tissue which filled the blastocoel and from which the entoderm of the alimentary canal was differentiated.

We thus arrive at the conclusion that the so-called pharynx of the Microstomidæ consists of two parts: (1) a "cone-shaped depression" homologous with the Polyclad pharynx, and (2) a "pharynx" homologous with the similarly named structure of the Triclad.

Water Vascular System.

In the living worm the water vascular system may be seen to consist of a light gray, almost transparent tube, with numerous fine branches. This tube opens to the outside at or near the posterior end of the body. Sometimes the opening may be seen in optical section, in the middle of the triangular area at the posterior end of the body, and sometimes it may be seen

near the posterior end of this area (Figs. 1 and 13, *op.*). It lies on the ventral side of the body.

The tube is formed at the posterior end of the body by the union of very many fine branches which are scattered through the dorsal part of the posterior end of the body. This tube, while it gradually increases in size, passes forward in a very tortuous course dorsal to the alimentary canal, and between the lobes of the brain to the point midway between and anterior to the ciliated pits. Here it makes a sharp bend toward the ventral side and increasing gradually in diameter pursues a much less tortuous course dorsal also to the alimentary canal to the opening at the posterior end of the body. In some worms the two limbs of this tube lie in the same horizontal plane between the ciliated pits and the mouth, while behind the mouth the larger limb lies ventral to the smaller. In other cases the larger limb lies ventral to the smaller throughout its whole course. The larger limb increases in size from the anterior end of the body to the opening at the posterior end. Thus there is a continual increase in the size of the tube from its beginning to its external opening. Over the anterior end of the pharynx the dorsal limb is $6\ \mu$ in diameter, and the ventral is $7\ \mu$ in diameter.

Numerous fine lateral branches, which are themselves made up by the junction of smaller branches, join the dorsal limb of this tube at intervals along its length. These branches are more numerous at the posterior end of the body and gradually decrease in number towards the anterior end.

It is with great difficulty that these fine branches may be seen. They are visible only in the smallest worms which have the alimentary canal nearly or quite free from food material, and are therefore nearly transparent. In favorable conditions in the living worm ciliary motion may be seen in the posterior end of the ventral limb of the tube, and also in both limbs near their junction.

In the longitudinal sections the ventral limb of the tube may be traced from the anterior to the posterior end of the body. In these sections, and also in cross-sections, the walls of this tube may be seen to be made up of a single layer of cubical, ciliated cells (Figs. 14 and 15). The length of their axes is $3.5\ \mu$. These cells are finely granular and have very large,

coarsely granular nuclei (*N.*) near their ciliated ends. The nuclei are from $2\ \mu$ to $2.5\ \mu$ in diameter. No nucleoli were to be seen.

The cilia (*C.*) as seen in sections are very fine and nearly fill the lumen of the tube. In macerating a worm I have been able to isolate from the body half the length of the ventral limb of the tube. In this condition the cilia were easily seen through the transparent wall of the tube.

The large amœboid cells which form a cup from the bottom of which a large cilium projects into the ends of the very fine branches ("Wimpertrichtern"), which Graff ('82, p. 107) describes for *Mesostoma Ehrenbergii*, and which Böhmig ('90, p. 242) describes for *Plagiostoma*, could not be found either in the living worm or in the sections.

Graff ('82, p. 101) says that the water vascular system of *Stenostoma leucops*, which was first described by Siebold ('45) and Schmidt ('48) as a simple loop at the anterior end of the body, was followed further by Leuckart ('54). Leuckart described it as an unpaired tube which opened at the posterior end of the body.

Graff ('75, p. 115) from his own researches says that it is a tube which in the greatest probability opens at the posterior end of the body. From this opening it runs to the anterior end of the body, following the median dorsal line. Here it makes a bend toward the ventral side, and proceeds backwards, ventral to its former course. Since he was unable to trace it back of the anterior one-third of the body, he surmised that the end of the smaller tube was divided into fine branches in the anterior one-third of the body.

Landsberg ('87*b*, p. iv) agrees with Graff in regard to the relative positions of the limbs of the tube. He states that the larger limb opens to the outside at the posterior end of the body, and also traces the branching of the smaller limb back as far as the middle of the body.

Zacharias ('85, p. 318), although he has not seen the connection, thinks that on account of their location, contents, and analogy to similar cells in other forms, the pharyngeal cells of *Microstoma lineare* are not digestive but excretory in function, and that they are in direct connection with the fine branches of the water vascular system.

Both Graff and Landsberg state that the smaller branching limb of the tube lies ventral to the larger limb.

Careful focusing upon the living worm which has been compressed under a cover glass shows that the fine branches of the smaller limb and the limb itself lie dorsal to the larger limb. In a favorable worm which is compressed these fine branches may be traced not only to the middle of the body, but to the posterior end.

From the fact that excretory cells ("Wimpertrichtern") have been described in connection with the terminal branches of the water vascular tube in other Rhabdocoels (*Mesostoma*, *Plagiotoma*, and *Derostoma*) there can be little doubt of their existence in *Stenostoma*. I have been unable to find these cells in sections and have tried numerous anilines, with a hope of finding a specific stain that would show them in the living worm, but always without success. As previously stated, methylin blue stains the pharyngeal cells without affecting the cells of the other tissues.

It has not been found possible to show by direct observation that the pharyngeal cells are connected with the terminal branches of the water vascular system, or that they are not so connected. If they are so connected, they are the specific excretory cells as claimed by Zacharias. They cannot be the *only* specific excretory cells, since we must suppose that every ultimate branch of the water vascular tube terminates in such a cell; and these ultimate branches are much more numerous in the region posterior to the pharynx than in the region over the pharynx.

There are, therefore, but two alternatives open to us. We must assume, either (1) that there are two kinds of specific excretory cells in *Stenostoma leucops*, one of which (the pharyngeal cells) is readily stained in the living worm by methylin blue, and the other of which remains unstained; or (2) that the pharyngeal cells are not excretory in the sense of being connected with the water vascular system, and that the true excretory cells of the water vascular system have not yet been demonstrated. All the observations which have been made seem to me to be opposed to the first assumption.

Nervous System.

Brain. — In a living worm as seen from the dorsal or ventral surface the brain may be seen to lie immediately in front of the oral end of the pharynx. By focusing upon the living worm it may be seen to lie in a plane dorsal to the pharynx and to be surrounded by the parenchyme, which appears to support it and hold it in place. The brain consists of two large ganglia lying one on either side of the median line with their posterior ends connected by a large transverse commissure.

In a horizontal optical section each of these ganglia is seen to consist of a large oval posterior part and a smaller blunt forward projection, the anterior end of which is excavated for the reception of the ciliated pits. As may be seen in both longitudinal and cross-sections, the two ganglia lie in the same horizontal plane.

When the ganglia of a quiescent worm are observed from above (Fig. 16), they are seen to be but $8\ \mu$ apart at their anterior ends, while they are $25\ \mu$ apart at their posterior ends, thus making the longitudinal axes of these lobes stand at an angle of about 30° with one another. The longitudinal axis of each of these ganglia is $50\ \mu$. The greatest transverse axis is $25\ \mu$ and the greatest dorso-ventral axis is $30\ \mu$.

In sections the ganglia may be seen to be made up of branched cells which may be seen in many places to be connected by their processes (Figs. 17, 18, and 19). Thus in Fig. 19, which represents a cross-section of the anterior part of the brain ganglion taken along the line *ab* in Fig. 16, the ganglion consists entirely of branched cells. In Fig. 17, which represents one-half of a cross-section of the posterior end of the brain taken along the line *cd* in Fig. 16, the ganglion consists of an outer thick layer of branched cells and a central mass of parallel fibres which are continuous with the fibres of the commissure. In Fig. 18, which represents a horizontal section of the brain, the part of the ganglia just anterior to the commissure consists entirely of branched cells.

These branched cells vary much in size as well as in form. The smallest are scarcely more than $1\ \mu$ in diameter, while the largest are $4.5\ \mu$ in diameter. These cells may be seen in

the sections to be finely granular and to have small round or oval, finely granular nuclei. The nuclei are from .3 to $1.75\ \mu$ in diameter. The structure of these amœboid cells is finely preserved in worms which have been fixed in either chrom-osmic-acetic acid or corrosive sublimate. When a corrosive sublimate section is stained with hæmatoxylin, the protoplasm of the cells takes a light purple stain (Fig. 17). In a section of a worm fixed in chrom-osmic-acetic acid and stained in alum carmine the nuclei of the amœboid cells took a dark purple red stain, while the cell contents took a light red stain (Fig. 19).

The commissure (Figs. 17 and 18) connecting the two lobes is seen to be made up of fibres and to be free from an investing layer of cells. It is cylindrical and has a diameter of $20\ \mu$.

In a cross-section of the commissure taken from a point midway between the ganglia it has the appearance of being made up of a very fine network of fibres enclosing round or polygonal spaces (Figs. 17 and 19). This network is more pronounced toward the middle of the commissure. The spaces are filled with a very finely granular substance. Toward the ventral side of the commissure large, light-colored, irregular shaped spaces may be seen, which appear different in character from the polygonal spaces in the centre of the commissure (Fig. 17, S.').

In cross-sections of a worm where a longitudinal section of the commissure is obtained this same network is seen to be present. In these sections the network is seen to enclose long, narrow spaces rather than the circular or polygonal spaces seen in the cross-sections. The greatest length of these spaces is parallel to the length of the commissure. The large clear spaces which were seen in the cross-sections are also seen toward the ventral side of the longitudinal sections of the commissure. Here they appear as long, narrow clear spaces (Fig. 18, S.'). The network is much more pronounced toward the point midway between the lobes of the brain. At the lobes the strands cease to form a network and run parallel to one another into the lobes (Fig. 18, Fi.).

In sections of the worm which had been treated by Kölliker's silver nitrate method (Fig. 19) the branched cells and the fibres of the commissure took a dark brown stain, while the material between the fibres was colored a light green.

Nerves. — In the living worm which has been stained with

dahlia (1:10,000) the brain becomes of a light purple color. Under these circumstances two nerve bands stained like the brain may be seen to run backward from the posterior end of each ganglion. The other tissues are not stained.

An outer very narrow and short band (Fig. 16, *S.N.*) runs from the dorsal side of the posterior end of each ganglion to the dish-shaped organs, and an inner much longer nerve band may be seen to run from each ganglion to the posterior one-half of the body. These lateral nerve bands (Fig. 16, *L.N.*) may be seen in sections to run on either side of the alimentary canal a little nearer to the dorsal than to the ventral side of the body. On account of their very small size it is difficult in cross-sections to distinguish them from the parenchyme. In longitudinal sections of a budding worm these nerve bands may be seen to connect the ganglia which are to form the brain of the anterior bud with the ganglia which are to form the brain of the posterior bud. In one of these sections (Fig. 21) the nerve bands may be seen to be made up of a single layer of small cells which are long and narrow, and the long axes of which are parallel with the long axis of the body. They are $4\ \mu$ long and $.75\ \mu$ wide. They are finely granular and are provided with small oval nuclei $.5\ \mu$ in diameter. At a point midway between the ganglia this nerve may be traced through three or four longitudinal sections $5\ \mu$ in thickness, thus making the nerve at this point from $15\ \mu$ to $20\ \mu$ in width.

Graff ('75, p. 414) says that when the worm is contracted the ciliated pits are embedded in the anterior end of the lobes of the brain, but when the worm is in its normal condition the brain is entirely separate from the ciliated pits.

I have not found a living worm in any state in which the ciliated pits have not been embedded in the forward projection of the lobes of the brain (Fig. 1, *C.P.*). Out of fifty series of sections of worms in all states of contraction not one instance was found in which the ciliated pits were not embedded in ganglion cells which were continuous with those of the posterior end of the brain.

Graff ('82, p. 259) says that according to Schneider ('73) the lobes of the brain are connected by a double commissure which surrounds the water vascular system. He also states that Hallez ('79), like all other workers, found but a single commissure.

By careful focusing upon the living worm the water vascular tube may be seen to run dorsal to the commissure. No trace of a double commissure can be seen in sections, while in cross-sections of the worm the sections of the water vascular tube may be seen to lie dorsal to the sections of the commissure.

Böhmig ('90, p. 252) finds that the multipolar cells of the brain of Plagiostomidæ have from three to five processes, and in opposition to Fridtjof Nansen, who says that a general connection between the ganglion cells is not acceptable, states that the cells are connected by these processes.

Böhmig ('90, p. 254), in speaking of the material making up the central nerve mass and the commissures of the brains of Rhabdocoels, says that in sections under a high magnification it can be resolved into a fine network. The meshes of this network are very fine and are thickened in many places by minute swellings. He agrees with Rawitz ('86) and Leydig ('85) in thinking that this network is present and that the minute swellings are due to the crossing of the fibres of the network. He says ('90, p. 253), "Die Fasern und Fibrillen dieser nervösen Substanz bilden ein Netzwerk, sie anastomosiren mit einander."

According to Böhmig ('90, p. 254) Nansen says that the tubes and fibrillæ forming the Punctsubstanz do not anastomose with each other. He says that the appearance of a network obtained in cross-sections is not a network, but the cross-sections of numerous tubes.

Böhmig ('90, p. 256) says that Rohde ('86) thinks that the finely granular material between the meshes of the network in Polychæts is food material for the nutrition of the nerve fibres composing the network and for the ganglion cells, while Leydig ('85) and Nansen think it is the "true nerve substance."

As before stated, it may be seen in sections which have been treated by Kölliker's silver nitrate method that the ganglion cells with their processes take a stain identical with that taken by the fibres composing the apparent network of the commissure. I was unable in any case to trace a distinct connection between an individual fibre of the commissure and an individual cell process, but in one instance it was possible to see a bundle of nearly parallel fibres standing in such a relation to a group of ganglion cells that they could hardly be interpreted otherwise

than as processes of these cells. These facts indicate that the fibres making the apparent network of the commissure are continuous with the processes of the ganglion cells, and that the fibres are the true nervous substance of the commissure.

There are three possible arrangements in which this nervous material might be placed in order to give the appearances which are found in both cross and longitudinal sections: (1) the arrangement in tubes as Nansen has described them, (2) the arrangement into a true network according to the theories of Böhmig, Rawitz, and Leydig, and (3) the arrangement into a feltwork of independent fibres which cross one another at an infinite variety of angles, but which do not anastomose to form a network.

The sections do not uphold the first supposition, in that the apparent network obtained in cross-sections appears very irregular and broken in many places. In longitudinal sections the fibres have the appearance of starting from the small processes of the ganglion cells. It is not probable that these processes enlarge and become hollow tubes as they proceed from the ganglia toward the median line of the body.

In focusing upon this apparent network it has not been possible to make out whether the fibres unite with one another to form a genuine network, or whether they merely cross one another so as to make a feltwork. In longitudinal sections of the commissure it may be seen that the apparent network is more pronounced at the centre of the commissure and also near the median line of the body. At the ganglia a network is scarcely visible, but nearly parallel fibres may be seen to run in small groups in different directions into the ganglia. Lines running from the ganglia in the direction taken by some of these fibres would converge to a point somewhere between the ganglia. If this apparent network be conceived to be made by the crossing of independent fibres which run in all directions from that part of the surface of one ganglion which comes in contact with the commissure to that part of the surface of the other ganglion which is in contact with the commissure, the appearance would be given in longitudinal sections of the commissure of nearly parallel fibres, or of a very slight network, at the ganglia, while the most pronounced network would be found near the median line of the body. In cross-sections of the com-

missure taken near the median line of the body the network would be much more pronounced at the centre of the section than toward the periphery. This is the exact appearance obtained in both cross and longitudinal sections. From the fact that we do not find in sections any prominent swellings where the meshes of the apparent network join, from the facts stated above, and also from a physiological standpoint, in that impulses would be likely to be best transmitted by entirely independent fibres, it seems more likely that the appearance of a network in sections is obtained from a feltwork of independent fibres rather than from a genuine network.

If the interpretation that the fibres are the real nerve substance be accepted, the granular material surrounding the nerve fibres may be regarded either as a nutrient material or as an inter-fibrillar supporting material. The fact that it does not appear in sections prepared by Kölliker's method to be identical with the pervisceral fluid indicates that it is in part at least a supporting material.

Sense Organs.

Stenostoma leucops has two pairs of sense organs, — the ciliated pits and the dish-shaped organs.

Ciliated Pits. — The ciliated pits are depressions of the integument located one on either side of the body at a distance from the anterior end of the body equal to one-half its greatest width. They lie opposite the anterior end of the brain (Fig. 1, *C.P.*). They open in a direction midway between dorsal and lateral, and are also slightly turned forward. In the quiescent worm they are shallow circular pits which, from a dorsal view, appear somewhat crescentic. The walls are very contractile, and the pits change their form from a broad, shallow cup to a narrow, deep pit which is directed backward and inward. The change of form of these pits is due both to the contraction of their own walls and to the contraction of the adjacent body wall.

In sections from a worm which was fixed in chrom-osmic-acetic acid, and which were stained in hæmatoxylin, the pits are seen to be embedded in the anterior end of the lobes of the brain (Figs. 20 and 22, *G.*).

The wall of each pit is made up of a single row of epithelial

cells (Fig. 22). The cells at the base of the pit are much smaller than those of the general integument. Each is 6μ in length and averages 2μ in width. They are coarsely granular and at their bases have large nuclei like those in the other epithelial cells. No basal membrane could be distinguished apart from the muscular layer (*Mu.*) which surrounds the pits.

No cuticle was discovered at the outer ends of the basal cells, but instead a thick homogeneous mass was seen to cover the cells. The cilia of the epithelial cells could be seen passing through this mass. In sections from a worm which was treated by Kölliker's silver nitrate method this mass was seen closely applied to the cells (Fig. 20, *W.*). In chrom-osmic-acetic preparations it is somewhat shrunken away from the cells (Fig. 22, *W.*). This mass is 3μ thick. The cilia on the small cells at the base of the pit are like those of the epithelial cells of the integument except that they are very much longer. They range from 8μ to 15μ in length. The cells at the sides of the pits gradually become larger and of the same character as those of the surrounding epithelium.

Graff ('82, p. 124) says that the ciliated pits of *Microstoma lineare* and *Stenostoma leucops* lie in front of the mouth, and that they show a great variety of forms. Sometimes they appear as long slits and sometimes as deep, cup-shaped pits. They are not only a sinking in of the epithelial cells of the integument, but of the muscular wall also. In *Microstoma lineare* their walls are covered on the side toward the body cavity with a continuous layer of pyriform cells which have round nuclei and dot-like nucleoli. As Vejdovsky described a "zierliche Zellenrosette" attached to the ciliated pits of *Stenostoma leucops*, Graff concludes that there is such a layer covering the ciliated pits of *Stenostoma* also.

Landsberg ('87*b*, p. 5) agrees with Graff with regard to the shape and position of the ciliated pits of *Stenostoma leucops*. He says that a nerve proceeds (probably) from the posterior ganglion lobe forward to a point just posterior to the pits, where it divides and sends a branch to each pit. At the pit each of these branches broadens out into a large ganglion which surrounds the pit.

In another paper ('87*a*, p. 170) Landsberg describes the histology of the pits as he obtained it in sections of a worm which

was fixed in corrosive sublimate and stained in Mayer's carmine. He says that the bottom of each pit is covered with a thick layer of homogeneous substance which may be regarded as mucus. Below this is a thin layer of ciliated epithelial cells whose cilia project through the homogeneous layer. Next to this is a much thicker layer which is made up mostly of pyriform cells, although there are other histological elements scattered through it. Next to this layer is the ganglion which is connected with the nerve. Landsberg bases this description upon a single series of sections.

As a result of a process of maceration he found in the pits : I, bipolar and some multipolar ganglion cells the processes of which form plexuses ; II, ciliated epithelial cells of various sizes ; III, partly membranous cells which have an investing function ; IV, goblet-like mucous cells ; V, a very regular network which stands at right angles to the muscle fibres ; and, VI, special sense cells. These last cells have one end drawn out into a long fibre, and the other end formed into a brush-like mass of fibres.

I have tried the methods by which Landsberg obtained his sections, but have been unable to confirm his statements.

Sections of worms which were fixed in either corrosive sublimate or chrom-osmic-acetic acid, and which were stained in either alum carmine, borax carmine, picro-carmine, or hæmatoxylin show the wall of the ciliated pit to be made up of a single layer of epithelial cells together with a muscular layer, both of which are continuous with the corresponding structures in the integument. These sections also show that the ciliated pits are embedded in the anterior ends of the brain ganglia. The same results are obtained in either longitudinal sections or cross-sections. Sagittal longitudinal sections through the brain lobes show no break between the ganglion cells surrounding the pits and those of the posterior end of the lobes which are connected by the commissure. In serial cross-sections no break can be seen from one section to another. I have seen no case of a nerve passing to the ciliated pits.

When the ciliated pits are developed, they are formed as simple depressions of the integument. There are three possible methods by which the two layers described by Landsberg might be produced : 1, by a division of the epithelial cells ; 2, by a migration of cells from the brain ganglia to the walls of the

pits ; 3, by a migration outward of some of the epithelial cells to form a second outer layer. On page 265 it has been stated that the nuclei of the epithelial cells divide by karyokinesis. If a new layer of cells were formed by the first method, we ought certainly to find numerous spindles vertical to the surface in every developing pit. No such spindles have been seen. In studying the development of the ganglia which surround the pits with regard to the second point, I have been unable to find any evidence of the addition to the wall of the pit of a layer of cells derived from the ganglia. The muscular layer always intervenes between the ganglion and the cells of the pit. With regard to the third point, we have no evidence that some of the cells do or do not migrate to form a second cell layer. In macerations I have been able to get nothing more than the ciliated epithelial cells.

Dish-Shaped Organs.

The dish-shaped organs are located near the dorsal surface of the body, on either side of the mouth, and just beneath the integument. They are surrounded and supported by the parenchyme. These organs have the form of a saucer. They are $10\ \mu$ in diameter. When a quiescent worm is observed from the dorsal side, the dish-shaped organs are seen from the side. In this view they have a crescentic appearance (Fig. 1, *D.O.*). The concave surface of the dish is thus directed forward. When the body is contracted, these organs are so turned that the concave surface faces dorsalward, so that when a contracted worm is observed from a dorsal view the organs appear circular.

In the living worm they appear to be made up of a single layer of from fifteen to twenty spherical or ovoid, highly refractive bodies. These bodies average $2.5\ \mu$ in diameter. By very careful focusing they may be seen to be connected with the posterior ends of the lobes of the brain by a very small nerve. These nerves are more plainly seen in the newly formed worms of a chain.

In a section which was parallel with the surface of these organs they appear to be made up of a single layer of round or ovoid bodies which are very coarsely granular (Fig. 25). These bodies take a very dark stain with hæmatoxylin even though the rest of the section is but slightly stained. In this they

resemble globules of mucus. Some of the bodies of the organs take a much darker stain than others. Small light spaces may be seen among these bodies. No nuclei were seen. No pigment is visible in these organs in either the living worm or in the sections.

According to Graff ('82, p. 116) Leuckart, in 1853, found these organs to be connected by a short nerve with the lateral nerves. Schneider, in 1873, found the organs directly connected with the brain by a short nerve, and also described them as hollow transparent spheres whose inner surface was covered with smaller spheres.

Graff ('75, p. 414) found them to be dish-shaped organs which are made up of small refractive globules, and stated that they are seen either in the face or in profile, according to the state of contraction of the worm.

REPRODUCTION.

In my study of the worm no trace of sexual organs has been seen.

The asexual reproduction is accomplished by a continual lengthening of the worm and a separating of buds from the posterior end of the body. Often more than one bud is present. Worms which have more than two buds are extremely rare, while those with two buds are often seen. The majority of worms have but a single bud, and worms which have no bud at all are nearly as plentiful.

The size of the worm when it begins to bud is different in different individuals. Sometimes a single worm is as long as a worm together with its first bud. The first bud is marked off a little back of the middle of the body so as to include a little more than the posterior one-third of the worm. When this bud is well developed a new bud may be seen forming between it and the anterior end of the intestine of the mother. When there are two buds the anterior bud is always much smaller than either the mother or other bud. In no instance was the bud seen to be forming a new bud while it was in connection with the mother. The worm always divides into two parts. The large posterior bud generally separates from the rest of the

chain before the pharynx of the younger bud opens to the outside.

The first sign of the bud is a very slight circular constriction of the integument which marks the anterior end of the bud. Just as this appears, a slight swelling is noticed in the living form on the medial side of each of the lateral nerves. These swellings gradually increase in size as globular masses of cells (Fig. 23). They grow toward the median line dorsal to the intestine. When they have nearly come together each puts out a mass of fibres which unite in the median line, and thus form the commissure which joins the lobes of the brain.

When the ganglia which are to form the new brain are about $20\ \mu$ in diameter, the integument of the side of the body just anterior to them may be seen to be pushing in to form the new ciliated pits. These pits gradually grow deeper and wider and embed themselves in the mass of ganglion cells. When the ciliated pits are well developed the dish-shaped organs appear. The nerves connecting these organs with the brain are then developed and can be seen in the living worm.

At the same time that the ganglia begin to form, a small mass of modified parenchyme cells may be seen between the intestine and the ventral body wall, and directly opposite the newly formed ganglia. This mass grows toward the middle of the intestinal cavity, pushing the wall of the intestine before it (Fig. 23).

A spherical lumen next appears in this cell mass, and as the mass gradually lengthens until it becomes ovoid in form, the lumen becomes long and narrow. By this time the outer border of this cell mass has become definite, and the periphery of the new pharynx is thus plainly marked. The cells around the lumen arrange themselves radially (Fig. 24).

The new pharynx is now so situated that the anterior end is next to the ventral body wall, and the long axis stands at an angle of about 30° with the long axis of the body. When the lumen of the pharynx first appears, a slight indentation in the ventral body wall may be noticed a short distance in front of the anterior end of the new pharynx, and just posterior to the furrow which separates the bud from the mother. This indentation deepens until it reaches the new pharynx, when the muscular wall of the integument is ruptured, and the borders

of the indentation become continuous with the periphery of the new pharynx at its anterior end. Here the epithelial cells lining the indentation come into contact with the cells of the pharynx (Fig. 24, *M.*).

The anterior end of the pharynx next opens to the outside by the separation from one another of the cells which lie between its lumen and the bottom of the indentation of the integument. This indentation of the integument persists as the cone-shaped depression which leads to the mouth of the adult. The pharynx remains in the condition stated above for some time, but at last its lumen comes into connection with the lumen of the intestine by the breaking through of the walls both of the intestine and pharynx. This happens just before the bud separates from the mother. While the budding is proceeding, the intestinal cells of the bud are full of food material which has been taken in at the mouth of the mother. In no instance was the bud seen to take food through its pharynx while still in connection with the mother.

While the new pharynx is developing, the parenchyme cells around it may be seen to be undergoing a differentiation. Traces of new pharyngeal muscles and pharyngeal cells may be seen surrounding the new pharynx (Fig. 24, *P.M.*).

At the same time that these new organs are forming, the constriction of the body wall which separates the bud from the mother gradually deepens until it touches the intestine. The wall of the intestine also becomes constricted at the same time. The intestine affords the last connection between the mother and the bud. When the constriction of its wall closes this connection, the bud fastens itself by its posterior end to some object, and the mother, by a few quick contractions, separates itself from it. The integument soon grows over the anterior end of the bud and over the posterior end of the mother. The integument at the posterior end of the mother continually grows backward until a new tail is formed. The separation of the bud from the worm is hurried if the worm is in any way irritated. Sometimes under the pressure of the cover-glass, the worm may be seen to divide, even though the newly formed organs of the bud are not yet completed. In such a case both parts swim about freely, and the organs of the bud are matured independently of the mother.

Sometimes when worms in which the bud is well developed are put into corrosive sublimate or osmic acid, the bud separates from the mother before the worm dies.

Graff ('82, p. 260) says that the asexual reproduction of *Stenostoma leucops* occurs in the same manner as that of *Microstoma lineare*, but he has never seen more than eight in a chain. On page 173 he says that the first sign of a bud in *Microstoma lineare* is a circular ridge on the outside of the intestinal wall at the point which marks off the anterior end of the new bud. This ridge is formed by a folding out of the intestinal wall. A septum is next formed, which runs from this ridge to the integument.

While this septum is being formed, a circular furrow of the integument is becoming deeper and proceeding toward the ridge on the intestine. While this furrow is forming, a thickening of the parenchyme cells is noticed just posterior to the furrow and in the median line of the ventral side of the body. This mass develops into the pharyngeal cells. At the same time a pit appears in the ventral body wall. This pit deepens and projects into this mass of cells until it touches the wall of the intestine. At the same time a cell mass separates off from either side of this pharyngeal cell mass. These two separated masses grow forward and backward and form the brain and œsophageal commissure.

The eyes are now developed. Next the pharynx breaks through into the intestine, long before the spontaneous separation of the bud from the mother.

Thus according to Graff's account the wall of the pharynx is developed from the integument, the brain is developed from the pharyngeal cell mass, and there is a connection between the intestine and pharynx of the bud for some time before the bud leaves the mother.

Wagner ('89, p. 191) agrees with Graff in regard to the number of buds, the forming of the septa and the circular furrow of the integument, and also in regard to the formation of the ridge on the intestinal wall. He says also that the brain of *Microstoma lineare* is first of the new internal organs to develop, and that this is formed, not from the pharyngeal cells, but from the lateral nerves of the body. Immediately behind the septum each nerve puts out a fibre mass

toward the median line ventral to the intestine and forms the commissure.

The eyes and ciliated pits are now developed. The ciliated pits are formed by a simple depression of the integument.

According to Wagner the wall of the pharynx is formed by a mass of parenchyme cells which appears on the ventral side of the intestine, and not from the integument, which has been pushed in through this mass until it touches the intestine. The depression of the integument stops at the ventral side of this mass of cells and does not go through it. The integument joins the new pharynx when its lumen opens to the outside. The pharynx opens into the intestine just before the bud separates from the mother, — not at any long time previous to the separation.

In *Stenostoma leucops* when it is budding I found no ridge on the outside of the intestine at the anterior end of the new bud, but rather a circular groove on the intestinal wall. No septa were seen. My observations on the development of the brain and ciliated pits confirm those of Wagner on *Microstoma*.

Graff ('82, p. 79) says that in those Rhabdocœls, which have the simple pharynx (*Microstomida* and *Macrostomida*) the pharynx is a simple depression of the integument forming a tube which connects the mouth with the intestine. According to this the pharynx of *Stenostoma leucops* is of epiblastic origin.

As was stated on page 271, there is a distinct line of demarcation between the pharynx and the cone-shaped depression of the integument leading to it. These two parts differ in the relations of the longitudinal and circular muscle fibres to the epithelial cells and in the character of the epithelial cells. The two structures differ also in their development, as has been shown by Wagner for *Microstoma* and by myself for *Stenostoma*. The walls and the lumen of the pharynx are formed within the parenchyme before there is any break in the integument, so that the lumen of the pharynx may open to the outside. The pharynx is formed directly from the ventral mass of parenchyme cells, not from a depression of the integument which reaches to the anterior end of the intestine. The depression of the integument reaches only to the anterior end of the new pharynx, thus forming the cone-shaped depression of the integument

which leads to the mouth of the adult. Here the cone-shaped depression joins the pharynx, and there is thus formed between them the distinct line of demarcation which was mentioned above.

As Wagner has also proven that the pharynx of *Microstoma lineare* is developed from the parenchyme and not from the integument, it may be inferred with safety that the pharynx of the Rhabdocœls is developed from mesoblast which is potentially hypoblastic, and not from the epiblast.

SUMMARY OF RESULTS.

I. The muscular layer of the integument is composed of circular and longitudinal fibres. The circular fibres lie next to the epithelial cells. The nuclei of the epithelial cells divide by karyokinesis.

II. The parenchyme is made up of a network and a perivisceral fluid which fills the spaces in the network. The network is formed by the fusion of individual cells which are connected by branching and anastomosing processes, and are separated by inter-cellular vacuoles.

III. The distal ends of the epithelial cells of the intestine are not ciliated, but are provided with long, slender, retractile, cilia-like, protoplasmic processes by means of which they take up the food material directly.

IV. The pharyngeal apparatus is divided into two parts, "cone-shaped depression" and "pharynx." The "cone-shaped depression" is developed from a depression of the ectoderm, and is homologous with the entire pharyngeal apparatus of the Polyclads. The "pharynx" is formed from the mesenchyme, and is homologous with the Triclad pharynx.

V. The smaller, branching limb of the water vascular tube extends its fine branches to the posterior extremity of the body and lies dorsal to the larger limb which opens to the outside at the posterior end of the body.

VI. The ciliated pits are formed from simple depressions of the integument. Their inner surfaces are surrounded by the anterior ends of the brain lobes. The structure of their walls is

identical with that of the integument, except that the epithelial cells are shorter and the cilia which they bear are longer than those of the integument.

VII. The dish-shaped organs are made up of a single layer of spherical bodies, and are formed in the parenchyme dorsal to the pharynx and posterior to the brain lobes.

VIII. The bud is separated from the mother by a circular constriction of the ectoderm and without the formation of a parenchymous dissepiment.

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This list includes the papers referred to. Those known to me only through the abstracts of Graff, Böhmig, and Korschelt and Heider have been marked with an asterisk (*).

EXPLANATION OF FIGURES.

<i>A.G.</i>	brain ganglion of the anterior bud of a chain.	<i>N.</i>	nuclei.
<i>B.</i>	brain.	<i>N'</i>	nucleoli.
<i>Ba.</i>	basal membrane.	<i>O.</i>	oil-globules in the intestinal cells.
<i>C.</i>	cuticle.	<i>Op.</i>	external opening of the water vascular tube.
<i>C.D.</i>	cone-shaped depression of the integument leading to the mouth.	<i>P.</i>	parenchyme.
<i>Ce.</i>	amoeboid cells in the parenchyme.	<i>P.G.</i>	brain ganglion of posterior bud.
<i>C.M.</i>	circular muscle fibres.	<i>Ph.</i>	pharynx.
<i>Co.</i>	brain commissure.	<i>Ph.C.</i>	pharyngeal cells.
<i>C.P.</i>	ciliated pits.	<i>P.M.</i>	pharyngeal muscles.
<i>D.O.</i>	dish-shaped organs.	<i>P.P.</i>	protoplasmic processes.
<i>Ds.</i>	dorsal limb of the water vascular tube.	<i>Pro.</i>	perivisceral fluid.
<i>E.</i>	epithelial cells.	<i>P.R.M.</i>	pharyngeal retractor muscle cells.
<i>E'</i>	stained bodies in the vacuoles of the intestinal cells.	<i>R.</i>	rods.
<i>F.</i>	cilia.	<i>R.M.</i>	radial muscle cells.
<i>Fi.</i>	nerve fibres.	<i>S.</i>	pharyngeal cells.
<i>G.</i>	ganglia of brain.	<i>S'</i>	spaces or chambers.
<i>I.</i>	integument.	<i>S.N.</i>	nerve running to the dish-shaped organs.
<i>In.</i>	intestine.	<i>T.</i>	tail.
<i>K.</i>	karyokinetic figure.	<i>V.</i>	valve between the pharynx and intestine.
<i>L.</i>	lateral branches of the water vascular tube.	<i>V'</i>	vacuoles.
<i>L.M.</i>	longitudinal muscle fibres.	<i>Vu.</i>	ventral limb of the water vascular tube.
<i>L.N.</i>	lateral nerves.	<i>W.</i>	homogeneous mass at the base of the ciliated pits.
<i>M.</i>	mouth.	<i>W.V.</i>	water vascular tube.
<i>Mu.</i>	muscle layer.		

EXPLANATION OF PLATES.

FIG. 1. *Stenostoma leucops*. Leitz, obj. 7, oc. 1.

FIG. 2. The integument from a longitudinal section of a worm which was fixed in chrom-osmic-acetic acid and lightly stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 3. Parenchyme from a longitudinal section of a worm which was fixed in corrosive sublimate and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 4. Parenchyme from a longitudinal section of a worm which was fixed in chrom-osmic-acetic acid and stained with hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 5. Pharynx and cone-shaped depression of the integument from a sagittal section of a worm which was fixed in chrom-osmic-acetic acid and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 1.

FIG. 6. Cross-section of the pharynx from a section of a worm which was fixed in corrosive sublimate and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 7. Pharyngeal cell from a longitudinal section of a worm which was fixed in chrom-osmic-acetic acid and stained in alum carmine. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 8. A part of a sagittal section showing the muscle cells connecting the ventral wall of the pharynx with the ventral body wall. The section is from a worm which was fixed in chrom-osmic-acetic acid and stained in alum carmine. The cilia of the epithelial cells of the pharynx are matted into a dense mass which took a dark red stain. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 9. The wall of the intestine from a longitudinal section of a worm which was fixed in chrom-osmic-acetic acid and stained in alum carmine. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 10. Epithelial cells of the intestine which were crushed from the living worm. Spencer $\frac{1}{10}$ obj. and Leitz oc. 3.

FIG. 11. Epithelial cells of the intestine which are filled with oil-globules from a cross-section of a worm which was fixed in chrom-osmic-acetic acid and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 12. Same as above from a worm which was fixed in chrom-osmic-acetic acid and stained in picro-carminate of soda. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 13. Diagram of the water vascular system.

FIG. 14. Longitudinal section of the ventral limb of the water vascular tube from a section of a worm which was fixed in corrosive sublimate and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 15. Cross-section of the ventral limb of the water vascular tube from a section of a worm which was fixed in corrosive sublimate and stained in hæmatoxylin. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 16. Diagram of the brain.

FIG. 17. Cross-section of the brain commissure from a section of a worm which was fixed in chrom-osmic-acetic acid and stained in alum carmine. Spencer $\frac{1}{10}$ hom. imm. obj. and Leitz oc. 3.

FIG. 18. Cross-section of one lobe of the brain, together with a longitudinal section of one-half of the commissure taken in a plane running through the centre of

the commissure. The worm from which this section was taken was fixed in corrosive sublimate and stained in hæmatoxylin. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 3.

FIG. 19. Cross-section of the brain commissure from a section of a worm treated by Kölliker's method. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 3.

FIG. 20. The anterior end of a horizontal section of a worm which had been treated by Kölliker's ('90) method. The section is not exactly horizontal, but is inclined so that the left ciliated pit comes in the sections dorsal to the one figured.

FIG. 21. Lateral nerve connecting the brain ganglia of two buds, — from a longitudinal section of a worm which had been fixed in corrosive sublimate and stained in borax carmine.

FIG. 22. Ciliated pit taken from a cross-section of a worm which was fixed in chrom-osmic-acetic acid and stained in alum carmine. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 3.

FIG. 23. Mass of parenchyme cells forming the beginning of the new pharynx of a bud, — from a sagittal section of a worm which was fixed in corrosive sublimate and stained in borax carmine. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 2.

FIG. 24. A part of a sagittal longitudinal section of a worm showing the newly formed pharynx of a bud before its lumen has opened to the outside. This section is from a worm which was fixed in chrom-osmic-acetic acid and stained in hæmatoxylin. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 1.

FIG. 25. The dish-shaped organs from a section of a worm which was fixed in chrom-osmic-acetic acid and stained in hæmatoxylin. Spencer $\frac{1}{8}$ hom. imm. obj. and Leitz oc. 3.

All of the drawings were made with an Abbé camera.