HIGLEY

MORPHOLOGY AND BIOLOGY OF SOME TUBELLARIA FROM THE MISSISSIPPI RIVER BASIN.

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Submitted in Partial Fulfillment of the Requirements for the

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IN THE

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MORPHOLOGY AND BIOLOGY OF SOME TUBELLARIA FROM THE MISSISSIPPI RIVER BASIN

BY

RUTH HIGLEY

A. B. Grinnell College, 1909.

THESIS

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY RUTH HIGLEY

ENTITLED MORPHOLOGY AND BIOLOGY OF SOME TURBELLARIA FROM THE MISSISSIPPI RIVER BASIN

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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In Charge of Thesis

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INTRODUCTION

Altho of seeming insignificance, the Turbellaria as a class present certain characters of morphology and life-history which make them of especial interest. Furthermore, their biologic processes and life habits in relation to other forms, shed some light upon general problems of common existence. A knowledge of any group of animals is of value from a phylogenetic standpoint as well as in the explanation of the interdependence among various types, so this group, standing, as it were, at a point of connection between the very lowest phyla, the aberrent parasitic worms, and the more specialized higher types, makes possible an understanding of one of the important steps in the evolution of the animal kingdom. The simplicity of anatomical structure and lack of conspicuous detail altho thus especially important in a comparative way, also enables these forms to carry on an existence almost unsuspected and generally entirely overlooked. The fact of the widespread distribution in both salt and fresh water passes, for the most part, unnoticed.

While the fresh water Turbellaria of Europe have been recognized and carefully studied for nearly one hundred and fifty years, the American species have received little attention. The earliest records for this country are those of Leidy. In 1848, he gave the first brief description of the now well-known and very

common *Planaria maculata*. He also studied rather completely *Phagocata gracilis*, distinguishing the fundamental points in which it differed from the *Planaria*. Later (1852) he added several other species to the list. No other studies were reported until a paper by Silliman appeared in 1885. This was also descriptive and systematic in character. The first morphological work was that by Ott (1892) who made the common *Stenostoma leucops* O. Sch. the basis of a detailed histological study. Woodworth (1896) and (1897) next published results of collections made from rather widely separated localities. He named four new species and added full descriptions of twelve others.

Since 1900, there have been a number of papers, a few descriptive, but by far the most the results of experimental work. Of the first type, the paper by vonGraff (1911) is noteworthy. In this, he gives descriptions and notes of some seventy-five species. Several other writers have from time to time added a few forms, but this is all. On the other hand, in a vast amount of experimental work the more common species have been used. Child's work with the common flatworm has explained a large number of facts of far-reaching general biologic significance. Other investigations, some of them exhaustive, have dealt with the more primitive rhabdocoels as well as with planaria. Among the many writers along this line are Kepner (1911) and (1915), Curtis (1905), Pearl (1903), and Keiler (1910).

Altho they are free-living forms, a few cases have been reported in which they are parasitic on molluscs and it is in these species that a beginning has been made in the study of the embryology and life-history. Two writers, Linton (1910) and Stanley C. Ball (1916) have published such investigations of a species living on Modiolus.

The Turbellaria of the central and western states are almost unknown. Woodworth (1897) and Stringer (1909 - 1913) have published descriptions of five new species from Illinois and Nebraska. Eleven other forms, found also in the eastern states, have been reported from a few localities in Illinois, Nebraska, Michigan, and Wisconsin, but these are all. That some species, at least, are present in great numbers is evident from the various collections for experimental studies. The whole Mississippi valley region with its lakes and almost numberless ponds furnishes conditions in many respects ideal for such types, and their existence will sooner or later be demonstrated.

In fact, both Planaria and rhabdocoelida are of much more common occurrence than is generally supposed and for several reasons are especially valuable for study. First, they are available as living reproducing animals thruout the year. Then, they are good for experimental work since they illustrate a somewhat primitive phylum, one in which the body structure is very different from that commonly encountered. Well adapted to such studies, by their simplicity and great vitality, they have come to be the classic speci-

mens employed both for elementary experiment and for complicated investigation. The free-living method of life, together with the simple fundamental anatomy, when compared with the specialized and much changed condition of the nearly related parasitic worms shows clearly the variations possible and actually brought about by a different mode of life. As a whole, the group is of more than ordinary interest.

Always considered of no importance economically, their possible relation to other forms has been overlooked, so that only by chance have their habits of parasitism and voracious feeding been discovered, and there is need of further investigation along this line.

In the present paper, a brief study is made of a few forms found in small lakes and ponds in Illinois and Iowa. This covers three phases: First, a summary and comparison of the types of habitat which deals with such environmental factors as flora, whether algae or higher water plants, animal communities, whether few or many, bottom, whether sandy or muddy, and also the general water conditions; second, a few of the biological aspects, this outline comprising a study of the reactions to the various stimuli; third, a morphological description of nine new species and additional data concerning twelve others. These descriptions embrace to some extent histological structure as well as gross anatomy, and a number of points regarding the distribution and characteristic variations of well-known species. In the case of one form, a

resume of the embryological stages is also given. Six plates which contain toto drawings of all the species are included, besides separate sketches of isolated parts.

The work was done mainly at the University of Illinois at the suggestion of Dr. H. B. Ward, and to him I wish to express my gratitude for help and inspiration. I also had the opportunity to make collections and to study at the United States Biological Station at Fairport, Iowa, and my thanks are due to the director, Mr. A. F. Shira, and to Mr. H. L. Canfield, who aided me in every way possible. I am also indebted to Mr. R. L. Barney, of the United States Biological Station at Homer, Minnesota, for material sent me, and to Miss Elizabeth Bodfish, of the University of Illinois, for many specimens from this locality.

TECHNIQUE

Collections were made in three ways. Surface or open water was dipped with a pail or jar, and as large amounts as possible carried back to the laboratory, partly for the purpose of ascertaining whether or not specimens were present, and partly for use in aquaria. Then with a long-handled dip net, masses of algae and water-weed were taken either from shallow places along the shore line, or from the surface out in deeper water where they floate in great tangles, or from the bottom. In some cases, a good deal of water was drained off and the mass of damp weed carried in, to be later plunged in pond or tap water. As a third method, the alga was taken with a minimum of disturbance, and kept as nearly as possible in its relative shape and condition. In small ponds where the water was not over three feet in depth, collections were made out in the middle and often the leaves and stems of water lilies and other large plants were gathered. These were kept by themselves in clear water. The stems and undersides of the lily pads were generally covered with very fine algae or a growth of diatoms, which made a good shelter and feeding ground for many small forms. The bottom mud with its loose covering of organic debris was generally dipped up separately, with a small amount of water. Samples were taken both near shore and out in the deeper portions.

Many collections were kept alive in the laboratory for lengths of time varying from a few days to six months. The algae and other debris were floated out in either tap water, rain water,

or pond water. Glass jars were used for this purpose, some very shallow and some eighteen inches deep. In cases where a few individuals or a special bit of water weed was to be isolated, shallow glass stenders could be employed. About half the aquaria were kept covered to prevent evaporation and the others left open, water being added at intervals. The amounts of sunlight varied. A few jars have been so placed as to have sun all day but most have had it for only a few hours at a time and a good many not at all. Generally the temperature of the aquaria was that of the room. A few however have been held at much higher and a few at a much lower point. Balanced and favorable conditions are always easy to obtain, and in a number of cases there was a good deal of asexual reproduction by budding, as a result of fairly perfect vegetative processes. Occasionally when a number of surrounding details were precisely favorable, even the sexual reproduction could be studied and the life habits made out with some degree of completeness.

The aquaria have never been artificially aerated, but an attempt has always been made to furnish oxygen by means of plant life. In the case of planaria, food has been provided in the shape of small bits of meat, while in the jars where rhabdocoels were living there has always been an abundance of other animal forms to supply all possible need.

In preparation for histological study, the specimens have been killed and fixed with some measure of success. The individuals in some cases were anaesthetized with a solution of cocaine

hydrochlorate followed by chloretone of varying strengths until they were quiet and expanded. The fixation was done with corrosive acetic solution. Material was generally stained in toto with Ehrlich's hematoxylin, embedded in paraffin, and sectioned 4 to 8 μ in thickness. A counterstain of eosin or erythrosin was sometimes used. With planaria, a solution of one part nitric to three of water gave good results as a killing fluid. Cold corrosive sublimate was found useful in many instances, and under special conditions a warm solution was valuable.

METHODS OF STUDY

Specimens were studied either alive or in permanent mounts. When living, they were controlled by means of a pipette and were isolated either in concave watch glasses or on a slide. The movements could be checked by burying in a drop of quince-seed jelly or by adding small amounts of cocaine or chloretone to the water. The jelly is of value in studying the cilia or the muscular system, for it increases the violence of action while retarding the speed. It also shows more clearly the relative position of various organs, for the animal will turn over again and again, thus affording good lateral and ventral views. The objection to its use lies in the fact that only a very thick, opaque solution will be dense enough to reduce appreciably the movement. The chloretone has the advantage of quieting thoroughly, but it also causes the specimen to become so limp as to be easily injured, and to begin to disintegrate very soon. Another way is to confine the animal by the weight of the cover glass or by a minimum amount of water on the slide. This method flattens the body so as to make it more transparent. The several organs will be pushed entirely out of their natural position but can be studied separately better than under any other conditions, since they can be partially isolated and their interrelationships made out. Because of the transparency and lack of rigidity, many details are clearer in the live tissue than in permanently mounted material, where a large amount of cellular contraction is

unavoidable. Many details of structure, especially those of the nervous system, are clear only from a study of prepared material. Serial sections in the several planes have been used to verify and correlate findings in the various body systems.

Some little difficulty is experienced in an attempt at a detailed study of the tissues. The extreme contractility and sensitiveness make it almost impossible to kill and fix material in a condition anywhere near the normal. The delicacy of the structure as a whole and in fact of all the organs, very much increases the chance of injury and even when great care is used, the tissues are generally somewhat torn or out of shape. The integument is so easily ruptured that often only the weakest anesthetizing fluids can be used, and then a complete quiet is not obtained. Then also the species which reproduce by budding very easily break off from the growing divisions and are likely to be mutilated. As a consequence of this, especial gentleness and care must be used in the handling and control.

FIELD NOTES

During the past two years, collections have been made in some eighty streams and ponds. About fifty places have been visited only once, a number of others two or three times, while from a few collections were made every few days for several months. The immediate surroundings, the state of the weather, the condition of the water, all vary to a greater or less degree. There were gradations from a sandy barren flat to a wooded hillside, from a hot July day to the intense cold of mid-winter, with five feet of ice thickness, from a few quarts of thick muddy water to a stream the size of the largest river. The types of places investigated may be summarized as streams, ponds, springs, and temporary mudholes.

The springs and puddles seem to be unfavorable for many of the smaller animal forms, except in a few instances, along the bluffs above the Mississippi, at intervals of one or two miles there are many springs flowing out from a more or less rugged hillside forming little gulches or marshy flats in their course of two or three hundred yards across the bottom land. The water is always clear altho in several instances there is quite a little sand washed out with the stream. The presence of the extra amount of moisture causes a great luxuriance in the nearby vegetation so that the little pools are completely hidden. In these pools and the trickles connecting them, there are often many entomostraca and insect larvae but very little or no filamentous algae to form a

lurking place for voracious species. The food supply is also nearly nothing, as protozoa, rotifers, and small crustaceans are absent. The hardness of the spring water coupled with the almost lack of organic matter explains the absence of turbellarian species in such situations. In one exception, where the location has made it possible and where the spring furnishes sufficient water to make a fairly permanent little pond, both the plant and animal forms have a chance to develop and are present in abundance. Here Stenostomum may be found in great numbers.

If puddles are made by the overflow from some stream or larger pond, then the plant and animal forms present will be those of the main supply which have become marroned. They will eke out an existence as long as conditions permit or will thrive if chance favors them. Thus in some years the rains are not so heavy as to violently stir up a pond, and then if the situation is partly protected from the drying power of the sun , the imprisoned fauna and flora may flourish thruout the season. It is very likely that the general life-balance of such heterogeneous colonies may be changed, perhaps several times in a few weeks, with the result that the total fauna will vary. At one time, a single species may be vastly more abundant than even in its natural habitat and then at another time, very little later, it may be entirely absent. In many other puddles made from either a source of clear water or by a heavy rain, aquatic insects will appear in twenty-four hours and a little later many protozoans. If the water remains for some

length of time so that filamentous algae have a chance to develop, there will probably be also many small crustaceans and an abundance of other life but no rhabdocoels. That is, species capable of finding transportation thru the air may gain a foothold in ponds where other species unable to do this will not. This, perhaps, explains first the presence of certain rhabdocoels in some mud-holes and not in others of different origin yet alike in general condition, and second the presence at one time and not at another.

The running water of streams and rivers does not produce situations favorable to delicate free-swimming organisms. Thus the type of turbellarian found in such places will be that capable of finding a sheltered and protected spot where there is also food and oxygen. In the Rock river, at Milan, Illinois, where it flows over six or eight miles of rocky bed, planarians find an ideal location. On the under side of nearly all the stones which project up from the bottom or out into the water or which lie against each other so that the underside is not buried, a number of specimens will be clinging. The stones are more or less rough, covered with tiny crevices which make good hiding places, the worm being almost below the surface and thoroughly protected but still able to make use of the swift current of fresh water. Collections have been made in several other localities upstream and within the limits of the rocky bed, but no planarians were discovered.

A situation similar to the above is found in the Salt Fork of the Sangammon, at Homer, Illinois, where, for a distance of

a few hundred yards there are many rocks and pebbles in the stream bed. The water runs sluggishly everywhere except at one point, and here there is always a swift current from the overflow of a dam. This is an ideal locality and living upon the rocks over which the water is continually pouring are many planarians, the only ones to be found either up or down stream. The Sangammon, itself, is another stream of this same type, generally slow-flowing with few or no stones. Scattering planarians have been found clinging to rocks at a place where there was a little fall and consequently a swifter current for a short distance.

The larger rivers with sandy or muddy bottom have, as a rule, a fairly even shore-line with few small coves or indentations, while a strong current generally keeps the banks washed clean of any driftwood or riff-raff which might lodge masses of organic debris and thus offer shelter to microscopic forms. On the side of the river where the current is undermining and changing the shore, no life of any sort is possible, but on the beach side, many clams, snails, and insect larvae find a a feeding ground. These, however, are able to anchor themselves firmly in sand, while such types as flatworms and small crustaceans cannot exist. Altho there have been at different times many collections made by various workers and at numerous points along the Mississippi, rhabdocoels and planarians have not been reported. This absence seems to be easily explained since the conditions in the river are vastly different from those of any of its tributaries. Forms carrying on

a thriving existence a few yards up some smaller stream meet with entirely new enemies and encounter a powerful current which will quickly dash them to pieces upon entering this expanse of water.

In the main branches of the Iowa, a like situation prevails, but here all along the course there are numerous small ponds left by its very habitual and periodic overflow. This backwater is generally protected by growths of willow and swamp maple, and may receive enough drainage from surrounding fields to last thruout the season. The plant and animal life is often very profuse and many Stenostomum forms have been taken at different times from such ponds.

Another type of stream which often becomes a suitable location for many microscopic species as well as larger forms, is the artificial ditch or canal. Here generally the water flows slowly and comparatively evenly, there is little danger of flood, and many types gain a foothold. The Hennepin canal presents conditions rather unique in these respects. The banks are riff-raffed with rough stones which make numerous crevices, the shore line being perfectly straight with never a break or an eddy to disturb the calm. There is movement sufficient to prevent the water from becoming stagnant but not sufficient to cause disturbance. The stones are covered with fine algae, which forms an ideal feeding ground. The larger crustaceans, predacious larvae, and even most of the microscopic species find it a poor situation, so that the rhabdocoel enjoys an existence singularly free from enemies, tho

on this same account the food supply is limited almost entirely to protozoans. Altho not plentiful in numbers, these forms are seemingly in control at least along the edge.

The most nearly ideal conditions for rhabdocoel existence are those found in permanent ponds. Here the water is comparatively quiet and the hunting grounds are sufficiently prolific.

In one such pond, eight collections have been made at intervals of from three to nine days, with essentially the same conditions and forms appearing each time. This was primarily a little stream racing thru an open valley protected by low hills on either side. The water is held back by an earthen dam to make a pool about thirty yards across, and with a depth of ~~from~~ two and one half feet in the middle. It is used chiefly for wading by the cattle in the pasture and is kept stirred into a thick muddy semi-fluid with little life of any sort. In direct contrast to this, below the dam for four hundred yards the water is clear, kept fresh by a little trickle coming thru the spillway, and filled with an abundance of animal and plant life. At first spreading out for one hundred yards and with a depth of three feet, it later in the summer shrinks to one half this size. The ground around is 'mucky' covered thruout the marshy portion with "Island Hay", then there is a region of Carex and Juncus. These, in the first place, harbor numbers of red winged blackbirds, secondly, their rigidity and harshness serve to keep away disturbing cattle, thirdly, act as a windbreak so that not even a ripple may disturb the surface.

of the pond. The water is more or less filled with masses of Nostoc, Spirogyra, and diatoms. The number of protozoans is very large, then, of larger types, as water beetles, dragon flies, snails, frogs, etc., there is no lack. Members of the genus Stenostomum are abundant everywhere in water from the surface where they swim freely, from deeper portions more or less muddy, and clinging to water weed, which, when taken in quite drained, will show great numbers. Out in the middle deeper portion, are large patches of Nitella, most of it nearly covered with organic debris and harboring many specimens. Taken from different portions of the pond there are some half-dozen species.

Another pool where many rhabdocoel species thrived, is in all respects a marked contrast to the above. This is Beatty Lake, a little body of water unique in its surroundings and formation. It is situated at about the level of the Mississippi river, not more than five hundred yards back from the shore line and with the ground level between them not more than six or eight feet high. The side away from the river is bounded by a mound seventy five feet in height which bends around to the southward, forming a nearly perpendicular wall on that side. Toward the north, the sand slopes away gradually. Surrounded on all sides by barren sand, the pond is essentially a 'hole' with the bottom so near the river level that the water never seeps away, and with enough draining in to prevent its drying up completely. On the west and south, the wind is entirely shut off, while even on the north and east the

ground is high enough to prevent much of a ripple ever disturbing the surface from that direction. There is almost no vegetation within a hundred yards of the pond in any direction. This is partly due to the blowing of the sand which covers everything. In one place, the bush-like branches can be seen, all that remains unburied of three tall locust trees. The pond bottom is sandy, very solid and smooth thruout. The banks slope very gradually into the water. It is covered around the edge with a thin layer of organic material deposited as the water slowly recedes a little, leaving some dead algae behind. The water itself is quite clear, from two to five feet deep, very warm at the surface and cold two feet down. Tho used by cattle to some extent for drinking and wading, the sand, when stirred up, quickly settles, leaving the water as clear as ever. There are no rushes, or other plants of this type, which reach up above the surface of the pond, so that the broad expanse is uninterrupted. Near the shallow portions, within the pond, are great masses of very coarse Spirogyra, showing very bright green against the sandy background. There are also patches of Nitella, heavy and dense, and sheltering at least five species of rhabdocoels, all active and well-developed specimens. In the deeper portions are large clumps of water lilies and several other flowering plants, such as arrowhead, and floating around at the surface, sheets of Cladophora and others of the low algae. Thus, while the plant life is very profuse, the animal forms are much fewer. There are, of course, many microscopic forms, but

larger types seem lacking. There are no frogs, clams, or snails, no water beetles, and only a few dragon flies. Out on the banks, a little sand toad is common together with four species of turtles and a little sand lizard. Altogether, the conditions prevailing seem to be ideal for several species of special interest tho not so favorable for most others.

A rather surprising situation was that encountered in an old boat anchored high and dry in a little clump of willows. It was protected from the wind and open to the sun so that evaporation would seem to have been rapid. However, the two or three tubs of water which the boat contained must have been put there two months before, at the time of high water, as there had been no rain. The whole boat was nearly filled with three species of conjugating Spirogyra. It was very luxuriant and harbored copepods, ostracods, diatoms, rotifers, and other lower algae. There were no insect larvae, as might be expected, but many species of protozoans and such simple organisms. There were rhabdocoels in abundance, the ever present Stenostomum and two other species, all thriving in their prison, a little world entirely isolated, but perfect.

Thirty yards away from the old boat was a muddy pond which well illustrates a different type of condition. Early in June, the overflow flood-water spread out over a forty acre corn field, much of it drained away and by the middle of July there was only a depth of a few inches. For a rod back from the actual

water edge, the ground was extremely mucky and soft down to a depth of eighteen inches. There were very large patches of mud-covered Nitella which seemed to be the only surviving species of plant life, growing all along the shore and out to a depth of ten inches. The water was 'thick' and black, with only a few animal forms, except in the case of protozoans which seemed to flourish. Stenostomum was the only rhabdocoel present and all the individuals collected were very long and slender. In a situation absolutely prohibitive for most species, the Stenostomum was almost the only form above the Protozoa which could carry on its existence.

Another very different type of pond are those of the United States Fish Commission. They are artificial in their origin and are always under control and present data interesting in comparison with natural conditions. The methods used to wipe out one species and further the existence of another throw much light upon the forces in nature which bring about these same results. These ponds are either cement lined or have a simple mud bottom. The depth and shape vary. Some are shallow, mere tanks with a smooth bottom, while others are long and narrow with a graded bottom giving half a dozen different depths. Often a number of half-partitions supply lurking places dark and secluded. The unlined ponds are generally open and broad with a depth varying evenly up to eight feet. The small tanks are about three by eight feet, while the largest ponds will cover an acre of ground. The water is supplied from a common reservoir, filled from the river. There is

always an intake and outlet thru which is supplied a constant and steady flow. The loss by evaporation is thus supplied, the oxygen content kept nearly standard, and the water constantly free from organic debris. The life conditions are much less complex than is naturally the case, since either fish or clams are the only large species present. The vast number of microscopic forms have found their way accidentally, and flourish because the situation is favorable. All of the ponds contain a larger or smaller amount of filamentous algae, water weed, and lower forms of plant life. This helps to furnish a never-ending supply of oxygen and a hiding place for huge communities of entomostracans and the like. There is no possibility of a sudden change in the several life factors, i.e., the conditions are constant and steady, a situation which is ideal for all sorts of types and makes the number of species very large. Even during the winter, down under the ice in the deeper parts, the stream of warm intake makes possible a continuance of almost summer conditions, and consequently there is not the wholesale killing off that generally follows the fall drop in temperature. Thus generation follows generation without a break, right through the coldest months. This is so much the case that every second season most of the ponds are drained and allowed to lie frozen and dry for several months in order to check the enormous multiplication of microscopic forms above the optimum for the species of economic importance. The cement tanks are also emptied every fall to prevent freezing, so that each spring the flora and fauna of

very many ponds begins anew, and it is of interest to see the rapidity with which both animal and plant communities manage to take up their existence.

Many other ponds, permanent and seeming to present conditions suitable for large annual communities, are more or less poor in such forms, and may also be said to be dead water, and many which contain various species will not show planarians or rhabdocoels. Perhaps the most influential factor in this poverty of fauna is the constant agitation of the water, which, when coupled with a variation in the amount, is sufficient to prevent much life. Then, too, many species are so retiring in their habits and spend so much of their lives hidden away that they escape notice even tho they are often present. Such is probably the case with many of the creeping rhabdocoels.

BIOLOGY

Any study of biologic conditions is at the outset superficial, and only the most general conclusions can be ventured. Definite and positive statements are to be questioned since so vast a number of factors is concerned, and it is often an impossibility to know or control nearly all of them. Consequently, many observations are qualified and results are guardedly and hesitatingly set forth. In studying any pond or stream, there are always many details of life habit which present themselves conspicuously, and many of the influences which bring about certain effects can be very clearly recognized.

Perhaps one of the most noticeable reactions is that to the amount of oxygen. For altho supplied with no tissue or organ by which to make direct use of oxygen or by which to effect an exchange of carbon dioxide, the Turbellaria are all quite sensitive to the presence or absence of either. The processes of respiration are carried on thru the skin, the parenchyma, and even thru the general cells of the body itself which are in direct communication with the surrounding water. Thus, altho the amount of oxygen necessary is infinitesimal, there is no reserve store, so that there must be a very constant source. In aquaria, when there begins to be only a slight overloading with carbon dioxide, many individuals can be seen making their way to the top where there is a layer of fresh water. Oftentimes this seems to be the only

method of driving certain species out from their hiding places. They are likely to remain near the top for days, staying quiet near the edge or very slowly gliding about just beneath the surface. Sometimes around the edge of the tank they will crowd up into the little film of water held by capillarity above the general surface. In balanced aquaria, on the other hand, large numbers are often hard to find, since even the deeper portions will be perfectly fresh. If, then, for any reason the balance is suddenly lost, up to the top will come several species. Some forms are habitually swimming free, and are much of the time to be found creeping over the surface or exploring pretty thoroughly the deeper regions, but under conditions of lack of oxygen, they will remain constantly in the uppermost water, avoiding the foul depths. Under normal conditions, many species find their most suitable habitat entangled in a mass of angae or creeping over bits of weed, probably as much for the supply of oxygen and consequent purer water as for a hiding place. This last conclusion is evident since in those pools where there is little plant life, all the specimens present will be found in close proximity to whatever bits of green algae there are, in the same way that any animal frantically clings to its last source of oxygen.

Planarians which live in vastly different locations from the above seem just as sensitive, for even tho their habitat is running water, not all parts of a stream are equally favorable. For example, the pebbles and rocks in sheltered, quiet pools

will show no specimens even tho the food is ample. If, however, at any point a little current passes thru, thus raising the oxygen content, there will be at least a few individuals. Out in the middle of the river, on the contrary, where the flow is exceedingly swift, making a boiling, seething torrent as it tumbles over stones, the oxygen content will be greater. Here the number of individuals in a given area is limited only by 'standing room', even dead clam shells and bits of wood being entirely covered. Thus it seems that in respect to their use of oxygen the turbellarians are not essentially different from other higher phyla.

All the turbellarians are, to some extent at least, sensitive to light, but they react toward it in very different ways, so that no general statement can be given. The presence or absence of eyes cannot be taken as the main factor in this response, for altho the eyes are primarily light detecting organs, species in which they do not occur may possess the ability to distinguish between light and darkness. The planarians and rhabdocoels live under such different conditions that a difference in reaction is to be expected.

The planarians are definitely and obviously negative in their response both to diffuse and localized light. In three species, common to this region, the eyes are large and well-developed. The animals live ordinarily under stones or in the depths of algal masses where a good deal of precision in their reaction is necessary. If placed in a large open dish, they will investigate very thor-

oughly every part and invariably come to rest at the point of greatest shadow. Their ability to estimate the size and density of the shadow is rather keen, since they seem able to distinguish even small dradations. Another factor which is perhaps to be correlated with the perfection of eyes is the relative amount of color. The pigment which here varies in amount with light and dark locations, is not present,at least to any degree, in forms which do not possess eyes, and it is not an unreasonable conclusion that color and eyes have evolved together.

The rhabdocoels have a more variable habitat and are not capable of as exact a response as the planarians, altho some species possess as highly developed eyes. The c olor has no direct connection, as for instance Strongylostoma, a form which has relativ ely very large eyes but possesses no pigment. This is also the condition in several Dalyells. The members of these two genera are positively heliotropic, except when the light is intensely localized. The genus Stenostomum, on the other hand, is without eyes or pigment, and has a negative response to light, be it strong ot weak. These forms do not habitually frequent deep, shaded places but rather a dimly lighted situation. This fact perhaps explains the rather general reaction, and their habit of being content with merely the less lighted regions. This habit, however, is constant, tho in just what way the light is sensed is hard to understand. As a whole, the genus Stenostomum is very simple in structure, all of the reactions being general rather than precise, and this re-

sponse to light is the most definite of all.

The effect of temperature in any detailed or definite way is very hard to ascertain, since it is of general influence, having to do with large quantities of water rather than with any very limited portion. In the broad sense, temperature is the main inciting force which every season starts or retards the life processes, and almost never in nature will it be found as a localized stimulus. During the winter, the ice confines the cold to a layer at the surface and to some extent limits and restricts the extent of its influence. It acts somewhat as a blanket,preventing the cold of the air from penetrating too deeply, so that beneath it a vast deal of life continues thruout the year. It seems certain that rhabdocoels remain in this layer of free water, which is, in fact, their regular habitat, rather than hibernating in the more protected bottom mud. Thruout the winter of 1916, collections were made from a single pond every week. During January and February, the Cladophora was dragged up thru a hole in the ice. Two or three species appeared in every haul, tho sometimes not in great numbers. It is of course evident that myriads of individuals are killed by the cold every winter, especially since by far the most live in the region of the surface and are frozen. Those which are driven to deeper water carry on their existence, perhaps with not so much vigor, but nevertheless very successfully. Another factor which must be taken into consideration in drawing conclusions is that, with the onset of cold, the manufacture of oxygen is cut off

and a large proportion of the descruction which occurs is a result of the absence of oxygen and the presence of an increasing amount of carbon dioxide. As an interesting side light, in artificial ponds where thru the bottom there is a constant stream of pure water all winter long, life continues with unabated vigor. This is, of course, due partly to the supply of oxygen, but the higher temperature also has much influence.

With the melting of the ice, in the spring, the relative conditions in the water are entirely changed. The ponds lie open to the warming influence of the sun and the response in many species is very ready. Thus it is that most planarians and many rhabdocoels become sexually mature at this season. To a great extent it is merely the change in temperature which incites greater cellular activity. Those forms which do not have their reproductive seasons at this time almost invariably go thru a period of very active budding or fragmentation which does not occur when the temperature is very low. Instances which well illustrate the power of heat are to be found in cases where a warm spring flows into a cold pond or stream. There, crowded into the water where the temperature is high, will be myriads of animal forms. Among these, planarians of all sizes are often very plentiful, while a few feet away, beyond the reach of warmth, there will be no specimens at all.

The lowering of the temperature in the fall has two definite effects. First, it retards the life processes of many species and, second, in a directly opposite way, it induces an

acceleration in the growth of the sexual elements. The first instance is the more common and has been referred to above. The second is rather difficult to understand. There are perhaps two theories to be offered in explanation. One is that those rhabdocoels which, in their primitive habitat, live in cold regions become sexually mature when the temperature comes the nearest to their ancestral condition. The other is that eggs which may develop slowly or lie dormant for some time if deposited in the fall, will be ready to begin a more rapid growth in the spring.

In the matter of food, the turbellarian is not fastidious. Many pieces of animal and plant material find their way bit by bit into the tiny and apparently inefficient mouth of the hungry hunters. Plant food seems to be second in choice, probably because the thick cellulose of its epidermis is too armor-like, is beyond the possibility of even receiving an impression from the delicate and jawless lips of these gentle feeders. Even the finest of the filamentous algae are themselves as large as many of the rhabdocoels and too stiff to be managed, while the lower forms, such as the flagellate swarm-spores and the like, are as a general rule too swift and active to be caught alive. Even the planarians seem to prefer a more easily assimilated food. When, however, algal cell walls are broken down, so that the inclosed cytoplasmic content becomes available, either free in the water or adhering to its original position, then it is greedily sucked up by almost any species. As soon as any of the lower plant forms begin to dis-

integrate, then they become a probable food supply.

The obtaining of animal food is somewhat more difficult, since only the soft parts can be used. The entomostracans, rotifers, and such types, furnish large amounts of food as soon as the individual dies, but they are seldom attacked when alive. In one instance, only, has a rhabdocoel been seen in an attempt on the life of a rotifer. For five minutes they struggled, but the rotifer held its ground and the rhabdocoel finally left. The chitinous shield of small crustaceans armed with spines or other projections is formidable, but as soon as the segments of the body thru disintegration begin to fall apart, then it is possible for the rhabdocoel to crawl inside and, thus protected, clean out the soft parts at its leisure. Protozoa are probably the nearest ideal food because their protoplasm is generally not so thoroughly covered as to be inaccessible and because they are common everywhere. In those species where a calcareous shell is secreted, the rhabdocoel swallows the whole, digests out the protoplasm, and then ejects the hard parts. The planarians, tho often dependent for their food on disintegrated fine organic debris, yet when the opportunity offers make the most stupendous efforts to obtain the flesh of higher animal forms.

As a whole, the turbellarians are scavengers, living generally upon bits of disintegrating organic matter. In the general life constituency of a pond community, they play an important part, constantly searching out and devouring particles which

might later be a source of bacterial growth. The smaller rhabdocoels can be found in great numbers, incessantly hunting thru the mazes of algae for dead crustaceans, etc., or burrowing and worming their way thru the loose earth-like masses on the surface of the bottom. Here they find what is left of myriads of protozoans and also other material either plant or animal which they speedily devour.

Ainmals with feeding habits such as these would seem always to have more than a sufficiency of food supply at hand. But this is not always the case. Under special conditions, other worms or larger species may keep the sources of disintegrating matter completely used up, or masses of debris may be entirely washed away to such an extent that a whole pond is cleaned of its food content. Under such conditions, the turbellarian does not die immediately. It goes thru a process of starvation so slow as to be almost unnoticeable. The individuals become thinner and smaller, and in some species may gradually shrink until they are no more than one-fifteenth their original size, at the same time becoming almost transparent in color. This explains the immense amount of variation in size of adult forms, the individual dimensions depending very directly upon the food taken. Planarians have been kept for eight months in clear water without food. The result was that at the end of the time they were still perfect individuals tho extremely small. Thus it seems that the food plays a very important part in the general appearance of most species.

The enemies of the turbellarians are few. Altho such

delicate animals are evidently almost entirely defenseless, they manage to carry on a fairly free and unhampered existence. The smaller species spend much of their time swimming slowly out in open water where they encounter almost all the other inhabitants. It is especially noticeable in aquaria where many species collect at the surface or towards the light that the rhabdocoels or planarians mingle constantly with the others, crawling over them and around them in the most unconcerned manner. And often two or three individuals will collide with each other without the slightest inconvenience or apparent fear. This is easily explained in the case of the planarians which are enormous compared with the tiny crustaceans, but the rhabdocoels are so nearly the size of the other common types that they would seem possible prey. However, a number of times rhabdocoels have been found gliding directly thru, between the valves of an ostracod unharmed, or resting contentedly under the carapace edge of some cladoceran.

This situation may partially be due to the fact that the crustaceans, themselves, habitually live upon disintegrating material and are not likely to attack living forms. Then, some of the rhabdocoel species possess nematocysts which would make them not only unfit for food but also rather well protected from most enemies. Others which do not possess stinging cells have especially developed dermal rhabdites in very great numbers. While these are not weapons of defense, they probably render the individuals unpalatable.

Perhaps the most effective method of protection is the general habit of retiring to well-guarded situations. The large planarian lying flat on the underside of some rough stone is in a fairly safe place, where few species are capable of dislodging it. The rhabdocoel hunts in some mass of alga where, at the same time, it is completely hidden from many large forms. If, however, it encounters an enemy of any sort, the rapidity with which it can contract enables it to disappear.

Part II. MORPHOLOGY

DETAILED MORPHOLOGY, Strongylostoma rosaceum

Introduction

Specimens were first seen during the early part of November, 1916, in the ponds at the United States Biological Station at Fairport, Iowa. They appeared together with other rhabdocoel species, both swimming free in the water and also coming out from masses of algae and water weed which were dragged up from the sides and bottom of the ponds. They were present in larger or smaller numbers in all the collections made during the next three months. Individuals of this species were easily recognized by the rapidity of their movements thru the water and by their habit of launching out openly rather than crawling over the sides of the aquarium on the plants. They were frequent in most of the ponds and the reservoir which supplied them, but in certain places where conditions seemed especially favorable they were very abundant. Such conditions were, in general, a large amount of filamentous algae rather than the coarser water weeds, a depth of water of not more than eight feet, and as might perhaps seem reasonable they were more plentiful in ponds where there were few fish.

These forms are of especial interest for several reasons. Both color and preciseness of structural plan are striking in intensity and definiteness. Among the more common rhabdocoels the color is nearly lacking or at least dull and varying with the

surrounding conditions from a transparent white to an opaque gray-green. In comparison with such fresh-water types, these specimens are gorgeous, for even tho obscured by muddy water the clear delicate pink is noteworthy, and makes them stand out sharply against the greenish background, easily distinguishable from all other animal species. While most rhabdocoels and even many Turbellaria are fairly simple structurally, in these the several organic systems are clear-cut and more completely developed.

Though occurring in large numbers in these special ponds, they have not been found in other ponds in this region, and members of this same genus have been reported from only three localities in this country. Altho they are probably present in many places and will be reported at some time, they are evidently not at all commonly living in the fresh water mud holes of the Mississippi valley.

The fact that in water under the ice the number of individuals is large and that the period of sexual maturity is during mid-winter, may be correlated with the northern habitat of related species. In a number of rather widely separated regions in northern Europe, numbers of this genus have been described, and altogether it seems to be a cold-loving form.

Special Technique

Specimens were taken from the ponds in pails of water in the common way, and then, one by one, removed with a pipette to small watch glasses or to a slide. For study alive, they with-

stood the presence of the cover glass better than other forms, since they do not easily or quickly break. Quince-seed jelly is not practical as only an extremely thick solution has any effect on the strong muscular movements. The best method is perhaps to quiet them with a solution of cocaine followed by chloretone. They are very resistant to anything of this sort and it requires large doses to produce a condition of quiet, and then disintegration is liable to begin in a comparatively short time. When the animals can be killed, corrosive acetic or colr corrosive solution used directly after they have become quiet with the anesthetic will cause little contraction. They can then be stained, cleared and mounted in toto, and most of the organs will be fairly distinct. Sections were cut from four to eight micra in thickness and were stained in Ehrlich's hematoxylin and erythrosin.

General

The length was taken when the animal was at the point of greatest extension or at least when moving unhampered freely thru the water, so that both anterior and posterior tips were drawn out to rather acute points. There were a number of very small individuals which were probably juvenile and not shrunken in size, due to lack of food. This seemed to be the case, since under starvation conditions, there was very little shrinkage of body size, most of the change being in relative amount of bulging in the intestinal wall. Those specimens apparently adult will vary from 1.0 mm. to 2.01 mm. in length, the average being within rather narrow

limits, 1.30 to 1.60 mm. The width is perhaps a little more difficult to compute, since it varies with physiological conditions, i.e., it depends upon the amount of food recently taken in and also stage of development of the reproductive organs. The limits of variation here are from 0.10 mm. to 0.35 MM., the average being 0.20 mm. to 0.35 MM. The greatest depth is very nearly the same as the greatest width, for altho the ventral surface is flat and the anterior part very low, the portion of the body posterior to the middle is very much elevated so that it is nearly cylindrical. Both the measurements of width and depth were t aken a t a point slightly posterior to the pharynx.

The amounts of expansion and contraction are v ery great so that measurements mean little except in a general way. A significant detail with r espect to shape is the amount of food in the intestine, or at least the abundance of food at previous times. This correlation of nourishment supply with shape variation is the result of the flexibility of the assimilative cells. Under starvation conditions, they are very minute and occupy no appreciable space in the body structure. When, however, the digestive sac is distended with nutrient material, these cells enla rge from five to ten times, and give the characteristic plump appearance to the animal as a whole. This species is especially contractile, so that it is able very quickly to accommodate itself to its surroundings. Under the slightest disturbance or fright, it may be drawn into an almost perfect sphere, the tips of the head and tail being

only the merest knob-like projections on the surface. The limits of extension are very much narrower, since there is almost no elongation possible and the animal, when moving, is always at its greatest length. All the changes in shape are more marked in the posterior middle part than anywhere else, the head almost constantly keeping its form. The term 'head' is used, since the anterior third of the body is conspicuously divided from the rest by a somewhat narrower neck-like portion. The head, itself, is rather sharply pointed in front, the angle made being about forty-five degrees. A little farther back, on each side, the outline angles again form two rather knob-like protuberances which are just a little in front of the eyes. Back of the eyes, the neck constriction begins. This is merely a curving in of the body wall, which soon begins to gradually bend outward again. As far back as the middle line (a point immediately posterior to the pharynx) the largest diameter is reached, giving an appearance of general plumpness. The posterior one-fourth narrows back rapidly to a slightly blunt point. Altogether, the shape is rather short and broad, with a triangular anterior end and a pointed posterior tip.

The color, which has already been stated as a delicate pink, varies from a pale rose to a deep terra-cotta, but is always of surprising brilliancy. This is apparent even to the naked eye, as is also the fact that it is only the posterior part which bears the color, while the head region is white. Usually, it is the cast that in most rhabdocoels there is very little if any tinge of

color, since the epidermis is not at all pigmented. Such a characteristic condition of the integument is found here, also, and the special rose tint is lodged in another tissue. As a result of metabolic processes, there is produced a very clear, light reddish-orange oil, which, in the shape of globules, is stored in the outside layer of the digestive tract wall, and, owing to the transparency of the epidermis, is distinctly visible. For this reason, that part of the body in which the intestine is situated is also that which is highly colored, while the anterior end, into which it does not extend, remains clear. The variable condition of the digestive wall as a result of more or less plentiful sources of food, causes very evident changes in color and also in the limits to which the color extends. Consequently, when the lobes of the alimentary tract are fully extended and reach far anterior, there will be some tint even in the head or, if there has been little or no food taken in for some time, then the whole animal will appear very light or almost white. Thus the color is in reality a by-product of the organic processes, rather than of especial intrinsic significance.

Epithelium

The integument is made up of a single layer of high columnar cells, in some portions carrying rhabdites and with a covering of cilia on the exterior. As a whole, it is an epithelium of the type found generally in the Turbellaria and varies only in many minor details of appearance and structure.

These high columnar cells make the epidermis a conspicuous body wall, a fact which is surprising on account of the extreme delicacy of the structure. Altho there is no cuticular layer, the outer boundary is very clear and distinct. This is due, not to thickness of material, but to compactness and a membrane-like toughness. The inner line of the epidermis is also well defined, tho not as dark and sharp as the outer portion. It is reinforced by a very thin basement membrane which helps to make a firm base of attachment for the numerous strands of muscle cells. Since almost the whole of the muscular system is, to a greater or less extent, connected with the integument, this layer must be able to withstand the stress of very nearly every contraction. The middle part, between these two clear boundary walls, is very transparent, since the cross walls show but little, and for this reason the shape and size of the epithelial cells is difficult to ascertain. This fact offers some explanation for the ease and frequency with which the cells break apart. Most of the minor injuries to the worm are tearings or breakings of this layer, which seems as easily healed again. It is probably of great advantage that the cells, because of their simple connection with each other, are able to repair an injury very quickly. Under conditions of injury, when the tension is released either entirely or only on one side, the cells very quickly become spheres, showing conspicuously their primitive flexibility and lack of specialized form. This flexibility is imperative when there is taken into

consideration the demands made upon the epithelium in the way of sudden contraction and expansion. There is an incessant and constant change in the amount of strain brought to bear upon a single cell or group of cells. For this reason, either in a small portion or in the whole layer the shape and thickness do not remain the same for any length of time and except when perfectly quiet the thickness is not the same for any two parts of the body. Under some pressure, the high columnar cells become flat, almost scale-like, and the layers consequently very thin. In general, the average thickness ranges from forty to one-hundred micra.

The external surface of the entire body is covered with a compact coat of cilia. These are distributed very evenly, not being grouped. There is also little variation in size as they are not longer or larger even at the tips of the head and tail. There are no sensory pits with large cilia and those around the edge of the mouth are also of the same general dimension. In shape they are slender spines with the base slightly larger than the upper portion, which is drawn out to a long, fine point. The length averages near the epithelium thickness, with a diameter of 3 to 6 micra, and they appear as extremely fine transparent lines. The vibrations are very rapid and tho generally the waves of motion are from anterior to posterior, yet upon occasion they may be reversed. Then, in different portions, the action may be at times entirely independent of the surrounding surface, continuing in some portions long after the main part of the animal has been killed.

Other structures included, or at least connected, with the integument are the rhabdites. They are arranged in two tracts in the anterior portion of the head. These are symmetrical and are placed one on either side of the middle line in the dorsal part of the parenchyma. The anterior half of each group is a broad, fan-shaped portion which extends to the very tip of the head, and back and down on each side nearly to the level of the eyes. This central broad part as it runs posteriorly along the middle line toward the narrow neck-portion of the body becomes itself very slender, like the handle of a fan, and thus continues back between the eyes for a distance. Then the posterior third of the whole group becomes wider again to about one-half the width of the anterior fan, and bends outward away from the middle line, reaching almost to the sides of the body. The outer posterior edge is truncate and straight, parallel with the side of the body. Another group of rhabdites much smaller than and lying directly ventral to the dorsal division runs backward at some distance ventral to the brain. It starts anteriorly near the tip of the head as a part of the dorsal fan-shaped group, and, bending ventrally, becomes very narrow just beneath the brain but broadens out again posterior to it. It ends abruptly under the extreme front end of the intestine. The rhabdites which make up these groups are arranged in strands of very regularly placed cells, each containing a cluster of rather large rods. In the anterior part there are from twelve to eighteen strands which narrow down to two or three, lying very

close to one another thruout the middle division, then in the remainder of the group there are from five to six strands broadening out a little. Each strand is composed of from ten to thirty clusters of rods placed end to end so that the whole appears as a series of long lines.

The rhabdites or rods are surprisingly alike in size, shape, and color. The average length in adult specimens is twelve micra, while the width or diameter is about two micra. When released from pressure of the body, these measurements remained constant. The shape is a rather bluntly pointed spindle. Thruout most of the length, the diameter of the rod is the same, giving them the appearance of a rather long cylindrical pencil. The two ends are about equally pointed, and generally slightly curved or bent to fit the contour of the bundle. The color was almost a steel white, not at all transparent, but bright and clear, with the edge very distinct and black. They seemed like bits of metallic rods sharp and hard, embedded in the most delicate tissue imaginable. There is always a rather constant number in each cell, eight, nine, or ten, lying very closely packed in a solid ovoidal mass. The cell, itself, is quite large so that the rods occupy only the center and are surrounded by a large space filled with very finely granular protoplasm. These rod-bearing cells are situated either in the epithelium itself or in the parenchyma just beneath, as tho they had been crowded there. The rods develop one at a time, right in the cell, being differentiated, as it were, from the protoplasm.

The rods in many instances lie with their points toward the surface and under very slight pressure were discharged thru the outside wall, seemingly by internal force, literally puncturing the cell. If, by chance, any entirely escape from the epidermis into the surrounding water so that all tension is removed, they immediately curl, sometimes tying a knot, and then spin around as they are swept away by the cilia-made currents of water. Even under slight disturbance in the body, they lose their straight position and appear more or less warped. Altogether the epithelium with its cilia and rhabdites is a very characteristic part of the body structure.

Muscular System

The muscular structure forms not a layer but a finely ramifying system of most delicate fibers radiating in all directions thru the body mass. The fibers extend from one part to another, intertwining and interlacing into a regular tangle which is complete enough in itself, if the rest of the body mass were taken away to preserve almost a perfect outline of the body organs. One has only to watch the constant movement of many portions of the animal ta make-up to realize the existence of very many contractile fibers. Since the worm is very sensitive in every part of its structure, every part must be capable of quick response. Since the habitat makes it necessary to find a way thru any jungle of water weed or debris, each individual must find it possible to wriggle thru any maze within which food and shelter lie.

The anterior end is, of course, the most sensitive region and, as a consequence, its musculature is well-developed, connecting the several head lobes with each other and with parts farther back. The muscle strands are extremely delicate, slender threads, most of them ventral to the brain ganglia. A very few extend directly across from side to side, a few others are oblique, but by far the most run from the different parts of the head back to the intestine or the integument of posterior parts. They might be described as clusters of fibers starting from some point in the main body region and spreading out fan-like for their insertion somewhere on the inner surface of the head integument. Since the head is very flat and there are few dorso-ventral strands, the whole complex forms a plate-like layer, very thin in front and becoming thicker toward the neck region.

The muscles of the posterior half for the most part run between the intestinal wall and the integument, anchoring and making both more firm. These are all rather short. Other strands run lengthwise or obliquely from one part of the outer wall to another, or, from a posterior region of the intestine to more anterior parts of the integument. There are also a few fibers reaching from dorsal to ventral points. Taken altogether, these groups of strands form a peripheral layer just beneath the skin.

On the ventral side of the worm, most of the muscle cells are connected in some way with the pharynx or mouth, and function as an apparatus for drawing in or protruding the surface. The

musculature of the pharynx itself is quite complex. There are comparatively heavy bands of fibers encircling both outer and inner edges of the rosette, while between the heavy petal-like cells very numerous more narrow strands diagonal back and forth. The circular bands act as sphincters and by the force of their contraction cause the pharynx to work as a rubber bulb exerting power sufficient to dislodge very solid particles of food material.

Connected with the reproductive system is a series of muscle cells, having to do with the control of the atrial pore and the discharge of sperm and egg cells. The atrial pore, situated at the tip of a larger or smaller papilla, is closed by the contraction of fibers lying near the ventral body surface. These are attached to the skin at one end and to the pharynx or neighboring structures at the other. In the walls of the reproductive organs themselves are flat, thin layers of delicate muscle made up of many cells lying parallel to one another and acting together as a whole. These may be said to be temporary, as they develop very rapidly at the same time with the sexual organs, and are quite thoroughly weakened by the end of the reproductive season.

Thus the muscular system has to do with the functioning of the several organs or with the specialized reactions of the different parts, acting separately and independently of each other. In this species, it reaches a greater degree of contractility than is generally the case in other forms.

Parenchyma

Parenchyma, or Mesenchyma, as it is sometimes called, is the term used to designate the tissue, or rather mass of cells, which fills the interstices between the several organs. It forms, as it were, the packing for the important parts which are thus buried and cushioned, fairly secure against at least minor injuries.

The cells which compose the parenchyma are irregular and variable in appearance. Soft and extremely pliable, spherical when free, very angular when confined, they depend entirely upon surrounding conditions for shape. Since they are not limited to any part of the body space, but accommodate themselves equally well to the large open portions of head and neck region or crowd into the infinitesimal cavities between intestinal cells, it is imperative that they be capable of very readily assuming any form. Correlated with such possibilities for variation is a very delicate and membranous cell wall. The nucleus is large tho so clear as to be impossible to distinguish from the protoplasm around it except in cells which have escaped into the surrounding water. The cytoplasm is thin, almost watery looking, and contains a few rather conspicuous granules, the whole structure being very simple.

In functioning, this type of cell serves several purposes. It takes the place of a circulatory system acting as the conductor for transfer of food materials. As it is in more or less direct contact with all the groups of cells in the whole structure, it forms a basis of connection between the digestive tract

and other regions. Where more highly specialized cells would preclude the possibility of such condition, these seem to be able to carry it on thru even a comparatively long series.

Another point of importance is the support which is given to the several body parts, the parenchyma acting in lieu of a skeletal system. Since there is not even a cuticle to give stiffness to the integument, and since none of the organs possesses the necessary rigidity in themselves, the shape is maintained by internal pressure. The animal is, so to speak, inflated so that it can hold its form, much as plant cells are made still and resistant by their turgidity. Then, too, the soft tissues are held in place and prevented from crowding one another so that their relative positions remain intact.

As well as serving for purposes of support, this most primitive of all the tissues also protects. It is very spongy, being capable of undergoing a great amount of compression, as for example when the animal squeezes thru an extremely small opening or when it bends or twists so that some one portion of the body is subjected to especial strain. The great amount of elasticity is also noticeable and causes the shape to vary. Thus, when the intestine is large and its wall thick, or when, during the period of sexual maturity, the reproductive organs occupy a great amount of space, the parenchyma is so compressed as to seem almost lacking. On the other hand, when the digestive cavity is empty and shrunken the whole body mass will appear to be composed of parenchyma,

the cells of other sorts being insignificant in comparison. In the case of injury, also, this valuable layer plays the main part. Forming scar tissue and furnishing cells for regenerative purposes, it seems embryonic in its ability to develop in various directions. It seems not far from correct to sum up the foregoing characters by comparing the parenchyma with the embryonic tissue of other forms.

Digestive System

The digestive system is more complex than that found in most of the other groups of this class. It consists of a very well-defined pharynx opening into a rather simply shaped, sac-like intestinal cavity, which occupies the greater part of the body space. So conspicuous is the whole structure that the general appearance of the animal depends entirely upon physiological condition. While all the other tissues are transparent and clear, the alimentary tract alone shows heavy and dark, giving the only suggestion of solidity and without which the individuals would seem altogether ephemeral.

Situated in the middle of the body on the ventral side, is the pharynx, which, viewed from above, is a large, sharply marked rosette. It is in reality an inverted cone or funnel with the small round mouth at the tip, opening down. The rosette is never entirely flattened, but slopes upward and outward to its connection with the intestinal wall. This connection is made with the very outermost edge of the pharynx, just above the large cir-

cular muscle band already mentioned. The lower, mouth-end of the cone is held in place by its attachment with the epidermis and by means of various muscle strands which also anchor it to portions of the ventral surface. There is no sharp line of demarkation between the external epidermis and the epithelium lining the rosette, so that the mouth is bounded only by the circular sphincter muscle. The pharynx wall, itself, is thick and heavy, due mainly to the size of the petal-like cells which, together with the muscles which control them, give the characteristic shape. There are from seven to ten of these wedge-shaped structures arranged with the smaller end pointing down toward the mouth. They are very rigid and act as a series of jaws. Criss-crossed between them and running in several directions are numerous strands of muscle fibers, which function in such a way as to vary the position of the rosette cells with respect to one another, and to make them of value in seizing particles of food and in controlling the food after it has been taken into the mouth. In structure and general mode of action, this resembles the bulbous pharynx of the Prorhyncidae, where the rosette cells number only four. The general shape of the whole rosette is changed very quickly and the complexity of its action makes possible a wide range of feeding habits.

The intestine into which the pharynx broadly opens is comparatively thin-walled. This bounding wall which is very transparent and elastic is made up of one or two layers of cells which act as an absorptive surface, and are subject to an enormous

amount of variation in size. When there is little food material either in the main portion of the intestine or in some part of it, the wall draws in, so that the cavity is entirely obliterated. This is brought about by the pressure of the surrounding parenchyma as well as by the compressibility of the lining cells. On the other hand, when there is need for greater amount of space in the alimentary tract, the wall is crowded out in all directions, portions of it compressing the muscle strands and other organs. The anterior end often reaches as far forward as the very tip of the head, pushing its way dorsal to the brain ganglion, and the eyes.

The digestive processes are carried on by means of these simple cells in the lining wall. In some manner, the food material is reduced to very minute clear globules which are often ejected as the result of slight pressure or otherstimulus. These globules are absorbed, converted during the process into an oil, and stored as droplets in the outer layers of the intestinal wall. These droplets are extremely variable in size and color. Those found in an individual at any one time will range from many which are just visible to some one-third as large as the pharynx rosette. The color is always very clear, a brilliant yellow-pink or some shade much darker. Generally, all the globules in a single specimen are of the same tint but there is the greatest difference among several individuals taken from the same very small aquarium jar.

These rather striking details in the structure of the digestive system are characteristic of this family and sharply mark

it off from all others.

Nervous System

The nervous system contains fewer cells and a smaller bulk of protoplasm than any other part of the whole structure. The several tissues and organs are so arranged that they are very easily reached by means of a rather scant supply of nerve material. The kinds of stimuli received are few, as a consequence the receptive apparatus is not at all complex and the problems of correlation and response are solved without great difficulty. A rather high degree of sensitiveness in certain directions and the possibility of a precise response seem to have been achieved with a minimum of anatomical detail. As a result of such primitive plan, the nerve mass is not sharply marked off into separate divisions but appears as a very homogeneous, almost undifferentiated whole.

The main or central part of the nerve tissue is the brain ganglion which is situated near the anterior tip of the head, on a line with the widest place. It thus lies near the middle of the head, between the main muscle strands and the eyes. There is a slight division into lobes which gives the appearance, at least, of a double structure, but as there is no suggestion of symmetrically arranged nerve branches or in fact any regularity of position or size of fiber, there is little to show a truly paired condition. The nerve cells are fairly large, but show little detail of development. The ganglion contains, also, other cells, either for nourishment or support. These may be distinguished by the fact that

they have no branches at all. It may, of course, be true that they later develop as true nerve cells. The- nerve connections can hardly be said to be definite trunks or even special nerves. Since they seem almost like projections of the ganglion, amoeboid in their promiscuous wandering. Most of the fibers, or nerves, as they may be called provisionally, find their way to the skin, spreading out over the inner surface and forming a layer of receptive material. Thus, these cellular projections are short, in the anterior region spreading out like many irregular rays from the ganglion, and become longer and longer as they reach farther and farther toward the posterior tip of the body. There are very few nerve strands extending toward the intestine and even the muscular system is poorly supplied. The greater part of the nerve mass is evidently sensory, and it seems the function of the motor nerves must be provided in some other way, perhaps by the direct responsiveness of the muscular tissue itself. Since there seem to be no cells purely associative in their activity, the various stimuli are probably passed from cell to cell. This fact would account for the relatively small number of cell branches in the ganglion. But however primitive the nerve tissue may appear, it very truly shows a great advance over that found in related genera.

Closely connected with the nervous system and acting almost as a part of it, are three types of special sense organs, namely, the skin, the few specialized tactile or taste cell groups, and the eyes. The skin seems highly receptive thruout its entire

surface and is evidently the most important medium of communication with surrounding conditions. Only one cell in thickness, it serves as a most efficient conductor of stimuli of probably all general kinds. That it is extremely sensitive is apparent from the great number of contractions constantly taking place. On the ventral surface of the head, there are several special groups or patches of more highly differentiated epidermal cells. These patches are each supplied with a special nerve branch and seem to be of value in selecting food, and in ascertaining more exact details as to environment so that they may be primitive taste or rather olfactory organs. They are composed of a cluster of several cells with rather heavy, rigid walls and denser cytoplasm. The whole head is generally in rather constant motion, parts are protruded or pushed around in all directions as tho investigating and locating any nearby source of food. It is with these sensory patches that such activity is carried on.

The most conspicuous development in the way of sense organ is the eye. This is hardly more than a light-detecting organ but is noteworthy because of its characteristic shape and color. The eyes lie one on each side of the middle line just dorsal to the brain ganglion beneath the epidermis. The carmine-red color of the pigmented portion makes them stand out sharply against the clear head region. This color varies somewhat in different individuals but for the most part is heavy, dark, and very opaque. The outside surface of this dark part is exceedingly rough, covered with

coarsely granular knobs. The shape, too, is irregular, very jagged, almost spiny, and often with flecks of pigment completely isolated from the rest. The position of the pigmented portion is quite constant. The pointed edge, which narrows outt o a sharp, bent tip, always is placed toward the middle line, at right angles with it, and directly opposite the eye of the other side. The remainder of the pigment is arranged like a cone-shaped cap with the much serrated external edge clasping a very transparent lens-like cell. This lens is all but invisible so that the inner surface of the dark cap can be distinctly seen much lighter than the outside, and also much smoother. The crystalline part is a solid bean-like structure, not ever exactly alike in the two eyes, and varying enormously in both size and shape. The nerve supply comes directly from the ganglion on whose surface the eye rests. It can hardly be said that optic nerves exist, since there are only clusters of cells which send branches or divisions of protoplasm up into the pigmented layer. It seems hardly possiblt that such an irregularly shaped mass could be capable of being more than a light-detecting organ, but the nerve supply would seem to indicate some true seeing ability.

The Excretory System

The excretory tubules are of the typical primitive type. They are protonephridia, rather large and well-developed, but exceedingly thin-walled and delicate, so that they are invisible except under very favorable conditions. The two long tubules have

their beginnings somewhere posterior to the middle part of the body and the extent and size are variable, so that in some individuals the tip may be very near the tail. The tubule, not at all constant in its position, wanders forward thru the parenchyma, quite deep below the surface, until it reaches the neck-region, where it bends dorsally around the anterior end of the intestine. In the head, it lies only a little way beneath the skin, being dorsal to the nerve and muscular systems. A little in front of the eyes and between them, the two tubules, one for each side, approach each other and then bend around ventrally, forming two loops. They then run back still in a ventral direction till they reach the edge of the pharyngeal rosette, where they empty. Thruout their whole length, these tiny canals are never taut, but are irregularly looped and folded so as to allow for a large amount of stretching without any strain to the delicate walls. The flame cells are difficult to find, owing to their diminutive size and the deeply embedded position of the tubule. In some instances, there are a number of these waving cells scattered thruout the length of the tubule, while often only one or two can be found. As a whole, there is so little variation from the common type that a general description will apply directly to most details of this form.

Reproductive System

Only during a rather limited period in the year are the reproductive organs to be found. Then they stand out definite and heavy, easily recognizable among the other more transparent organs.

The season of sexual maturity extends from about the first of November till the last of December, and during this time a single individual will produce several eggs. The animals are hermaphroditic but do not possess so complicated a series of organs as is generally to be found in this class. In brief, the reproductive organs consist of a paired testes, a single ovary, with small vitelline glands and an atrium seminalis which opens to the exterior by a short canal and pore situated on the ventral surface. The organs lie close together just posterior to the pharynx rosette, ventral to the intestine but to a greater or less degree displacing it. The group of parts thus formed makes a noticeably clearer region, oval in shape, much larger than the pharynx in extent and lying in the middle of the body. The two testes are situated on the right and left of this transparent part, with the ovary between them and in all three instances the ducts open forward and ventrally into the atrium. The vitelline glands, having their connection with the ovarian duct, ramify for a short distance among the adjacent lobes of the intestine. During the development of the egg, which takes place in the atrium, the other organs become crowded to either side.

The organs, themselves, are characteristic and vary little from the general type. The testes are spherical with a rather large duct leading to the atrium. This duct is very broad at the point where it leaves the testis and narrows gradually toward the opening, which gives it a funnel-shaped appearance. The wall of both testis and duct bear a layer of muscular fibers lying parallel

to each other. The wall is, however, of sufficient transparency to reveal the mass of sperm cells lying within. Thruout the whole reproductive period, the testes were tightly packed with sperm, all seemingly mature at least in size. The ovary varies a good deal in size at different times during the sexual period. It is made up of a mass of extremely large cells packed closely one above the other, crowded into narrow plates, from six to ten completely filling this organ. The shape is that of a pear but varies slightly toward an ovoidal. As the eggs become mature, at the lower end, they round out and draw away from the mass little by little until they escape into the duct leading to the atrium. Fertilization probably takes place while the egg is still in the canal, which is very short, or at the time it reaches the atrium. The immature eggs are thin-walled with very large nuclei and finely granular protoplasm. By the time the last egg has become mature, the ovary is very much diminished in size and is ready to almost disappear. In the atrium, which by means of its heavy wall becomes the egg-capsule, the ovum goes thru the maturation stages, develops the yolk-cells, and gains the heavy wall so characteristic. The atrium lies on the median line and as the egg enlarges it becomes more and more conspicuous. By the time the ovum is ready for laying, it has a size nearly equal to that of the pharynx and has stretched the atrial wall to the limit so that the pressure is great and only a small amount of displacement will cause it to be extruded. The canal leading from the atrium to the external pore is short and

held firmly in place by the surrounding tissues, but possesses a most elastic wall so that very quickly, when the pressure is sufficient, it enlarges many times to allow the passage of the egg. The pore itself has a very flexible wall, the epidermal cells flattening and lengthening to an almost unbelievable degree. At the close of the sexual period, the organs are very much depleted and have shrunken, losing also the definiteness and toughness of the walls, so that the whole appearance is very different from that of the earlier period.

DEVELOPMENT, *Strongylostomum rosaceum*

Individuals carrying eggs were first noticed about the middle of November, and a few were found in every haul made during the next four weeks. One more appeared on the twelfth of January, but none later In all cases, these individuals were not as generally opaque as those not sexually mature, i.e., the intestine was not so clogged with food, and oil globules were present in only small numbers. The body was also much more slender, indicating either that the regular amount of food had not been taken or else that the strength was being used for the nourishment of the egg. Altho sensitive, they moved around less actively than the others and seemed to be almost lacking in vigor.

The egg, which develops singly, is carried in the atrium seminalis and is visible because of its opaqueness even to the naked eye. It appears as a thick whitish spot, a tiny spherical knob causing the surface of the body to bulge a little on both dorsal and ventral surfaces. Under low magnification, it shows as a red-brown sphere, surrounded by a capsule made by the wall of the atrium. A little smaller than the pharynx rosette, this capsule generally lies just posterior to it and near the middle line of the body. On account of the transparency of the body and the heaviness of the egg, it appears as conspicuous as the rosette itself. The egg capsule though retaining its relative position in the body parenchyma is very movable, recalling a balloon buffeted about in

all directions but anchored to one spot by its tether, which latter is comparable to the short canal leading from the atrium down to the pore on the ventral side of the body. This pore is generally almost invisible, but, under some conditions, it is drawn up into a rather large papilla, just posterior to the pharynx. This drawing up is due to the contraction of muscles in its walls and in the surrounding integument.

As soon as they were discovered, animals carrying eggs were isolated in small watch glasses, where they were kept in about five cc. of water taken from the aquarium jar in which they were found. These jars had been filled with water containing a greater or less amount of algae, water plants, many crustaceans, other rhabdocoels and an inch or more of mud and sticks at the bottom, in every way very much like the natural pond except in temperature, which was slightly variable--the room temperature. The temperature was, of course, very different from that of the water under the ice in the ponds, but seemed to have little effect on the development other than perhaps to hasten it. This appeared true from the fact that in the hauls made every few days young individuals were constantly found in increasing numbers and of several sizes up, from those smallest and evidently just hatched. When isolated, the individuals soon came to rest and easily accommodated themselves to the new surroundings. Since the watch glasses were so small, there was some change due to evaporation, but this was as slight as possible because they were constantly watched and

the water replenished or completely changed. In order to prevent too much evaporation, they were kept covered with beakers. Part of the time the water was changed every three or four hours, and part of the time once in forty-eight hours. The water used to replenish was either clear, from the reservoir which supplied all the ponds or else taken from the same aquarium as the individuals themselves and then carefully freed from all crustaceans and other small forms.

At first, the eggs were rolled around and moved by the force of the water from the pipette. They then either floated for a little time or slowly sank to the bottom. Two finally settled to the bottom and became fixed by a secretion of cement, so that their position remained absolutely unchanged thruout their incubation period. Others were rolled around more or less at different times. The parents were removed from the watch glasses just as soon as the egg was laid in order to prevent contamination of the water. Altho the individuals were isolated at different times during the day, in all cases the eggs were laid sometime late in the afternoon, the earliest at 2:30, the others about 5:00. It appeared that when the egg was ready or nearly ready for laying, it required only a slight disturbance of any sort to bring this about. For example, in the case of egg number four, which was laid at 2:30 P.M., as the stream of fresh water entered the watch glass from the pipette, the animal somewhat aroused, contracted only slightly, but moved rather quickly about the dish for a moment, and

just that small amount of extra contraction was enough to cause the egg to be extruded. In all the other cases where the egg was laid several hours later in the day, the parent was quiet, more or less drawn up, clinging to the side of the glass or resting on the bottom.

The eggs vary slightly in shape, size, and color, showing perhaps the individual character of the mother. Never quite spherical, they can hardly be said to be ovoidal, the measurements averaging 14.5 by 14 micra. The outline of the egg is thus a very round-ovoidal. Sometimes, however, one end is more pointed than the other, giving almost an ellipsoidal appearance. That the shape is far from perfect was evident when the egg was rolled over and there came into view variations in the outline and in the amount of bulging in the different parts of the surface. The color is a rather clear deep yellow, verging a little on the red and brown, and is lodged entirely in the shell. This was demonstrated when the egg was broken and the white yolk was lost or when the embryo escaped after hatching, leaving the empty yellow shell. To the naked eye, the egg was a reddish-brown speck just barely visible, and appearing quite dark. Under some magnification, and with reflected light, the yellow was much stronger altho the influence of the white intensive portion of the egg was more noticeable. The shell though rather thick and heavy is quite transparent and clearly shows the yolk granules in the younger stages and the details of embryonic structure in the later.

Fig. 10 shows the egg as it appears during the first few hours before segmentation has begun. The yolk granules give a cellular appearance and near the center can be seen the nucleus, rather large and with a heavy wall. The granules vary in size, some being not more than one-quarter as large as others. They are slightly milky, somewhat transparent, almost a pure white, irregular in shape, somewhat angular, due partly to pressure, and closely packed. When the egg is broken, the granules escape into the water in a mass, the individual ones adhering quiteclosely, and holding their shape even when separated. Very little change could be noticed during the first six hours, but soon after that the even appearance was lost, as at different points there seemed t o be a breaking or drawing apart of the granules, showing lighter streaks. During the first twelve hours, the first and second cleavage s tages were finished. The divisions were not distinct, showing very clearly only at the edge where a notch marked the rounding of the cells.

By the end of the first thirty-six hour period, the cell divisions were much more distinct, the cells had attained a spherical shape and had arranged themselves definitely. The macromeres could be distinguished drawn to one side of the egg w hile the four micromeres appeared toward the c enter and opposite side. At different times, the nuclei of all the cells were visible as small, round shadows. The spaces left by the formation and shaping of the cells was become more transparent so that t he outlines were distinct and the whole aspect of the egg was changed, i.e., the cells were

adhering to- each other only slightly, but still one integral mass, and were floating in the surrounding fluid. The macromeres were very large, about one-sixth the size of the egg and were placed in a hollow plate, while the micromeres, somewhat smaller, lay curved inside. By turning the egg slightly, different views of the various cells could be obtained, and their relations made out.

During the next few hours, the division stages continued. In many cells, the new walls could still be distinguished but the mass soon became so solid and opaque that it was impossible to follow the cell lineage with any degree of accuracy. The two poles of the egg were marked by the difference in cells which at the micromere or animal pole increased in numbers, and soon filling- it began to push down as a cap over the large macromeres. At the beginning of the third day, the cap of small, compact cells had extended more than half way over the egg, giving a typical gastrula stage. This was very conspicuous and characteristic, as the cells at the animal pole were dark and heavy, while the free portion at the opposite end was clear and transparent. During the third and fourth days, the mass of cells in some places grew to extend all the way around to the ventral side.

The changes which take place during the fourth, fifth, and sixth days are those striking in their effect upon the appearance of the embryo. During the fourth day, the appearance is that of a mass of cells surrounded by a thick wall. It is at this period that the xxx anlage of the various organs differentiate them-

selves and instead of a mass of cells the several tissues and organs begin to be apparent. The first noticeable change is in the wall of the embryo which develops into a clear, very thick layer so closely attached to the inner surface of the shell that it seems to be merely a lining membrane. That this is really the integument or epidermal layer of the young worm becomes evident when, thru the lengthening and expanding process, this wall is folded in, away from the shell. Both outer and inner boundaries of the epidermis are sharply defined, so that the latter is a conspicuous portion of the embryo. The extreme thickness of this layer may be explained by the cramped and contracted position. During this same period, the muscular system begins its growth as many strands of cells attached to the firm inner wall of the integument. Thruout the following days, there is an increasingly greater amount of contraction and movement of the whole surface of the embryo. It is constantly being spasmodically drawn in at one point or another for a minute, and then slowly released, as tho the different fibers were each receiving their quota of exercise.

About this same time, also, the anlagen of the intestine made its appearance as a mass of cells nearly in the center of the egg, the connection withthe mouth not taking place until later. It was merely a plate-like layer of cells at first, without any of the lobular ramifications of the adult organ. Little by little, out thru the parenchyma, small strands of cells became differentiated and enlarged as branches of the main portion of the digestive tract.

Both anterior and posterior ends began to lengthen so that the spherical condition was gradually lost and the much folded, much crowded elongate worm was distinguishable. The two extremities were clear and very conspicuously different from the heavy, dark middle portion. In the anterior end, the mass of cells which forms the brain ganglion began to take shape and a little later the eyes could be seen. The two loops of the excretory tubules as well as the strands of rhabdites were visible. There was constantly a very slow rotating of the whole worm in the shell. It took sometimes from one and one-half to two hours for the whole embryo to turn completely over and it was rather difficult to distinguish the different parts, as the embryo was much twisted. At other times, the movement was much more rapid for a minute or two, and then the embryo would remain quiet for some time.

By the morning of the seventh day, the work was slowly twisting and turning almost constantly, often making a complete rotation in a few seconds. About this time, at points where the integument was drawn away from the shell, in the space thus left long and well-developed cilia could be seen vibrating rapidly in their close quarters. As soon as the wall returned to its position against the shell, the cilia flattened down and were again invisible, altho their influence must have been felt as aiding in the movement of the body as a whole within the shell. It was to be seen, however, that the development of the cilia was parallel with the increase in the rapidity of motion, altho the muscular system

also had something to do with this motion. The intestinal tract was beginning to have a more definite boundary and to extend both forward and back, and to a slight extent around toward the ventral side. During the latter part of the seventh day, the eyes began to be distinguishable as very irregular brownish-red masses. They were almost crescent-shaped with the center somewhat pointed and jagged. They lacked, however, the extreme roughness of the adult form.

By this time, also, the several folds of the integument were lost and the worm had straightened out, doubled only once upon itself with one long fold cutting thru the middle of the egg so that the anterior and posterior ends lay against each other at one side with the dark mass of the digestive tract around on the other side. Thus, the whole ventral surface was turned toward the center.

During the eighth day, one side of the egg showed a fine, dark line running around a portion about the outer surface of the egg. This line became more and more distinct and appeared like a crack in the shell. Its significance was explained later. The rhabdites at this time were still very small and difficult to distinguish on account of their transparency, but were fast taking the shape of the adult condition. They were arranged a few in each cell but the number for a cell was smaller than in the adult. The mouth and pharynx rosette were also nearly complete. The two heavy, perfectly circular muscle strands and the intervening ro-

sette muscles were complete. The reproductive organs were not developed, the atrial pore not broken thru, the papilla showing only as the merest suggestion of an elevation.

The embryo was, by this time, very often rotating within the shell and was almost constantly contracting one portion or another. The intestine now extended well up toward the head and back almost to the end of the body, where it was broader and thicker. In a lateral view, it could be seen extending ventrally to the rosette and the ventral wall. Several rather small oil globules appeared in the wall, giving the characteristic orange color. These, however, were very few in comparison with the number which showed even immediately after birth. The embryo had, by this time, evidently begun its metabolic processes and was an almost perfect individual.

During the first few hours of the ninth day, the ring in the shell became very conspicuous as a point of cleavage and gradually, bit by bit, the cap-like portion pulled away from the rest, lessening the pressure within the shell and causing a cessation in the movement for the time being. Later, the embryo began struggling again, the force finally splitting the cap more than half way around and allowing it to spring up so as to permit the little worm to squeeze out thru the opening, leaving the empty shell intact. The cap fell back almost into place. The newly hatched worm very closely resembled the adult except in size. It moved about very slowly at first, then more rapidly, and in a short time

was taking food in the same manner as adults. The color was that of the adult except that it was very much lighter. The length was 0.75 mm. by 0.60 mm. to 0.86 mm. by 0.65 mm. The animal was little more slender than the adult.

LIFE HABITS, Strongylostomum rosaceum

The surroundings and immediate environment of these forms are much the same as those for other rhabdocoel species. S. rosaceum lives in ponds containing a rather large amount of green algae and perhaps some few other water plants with usually a muddy bottom, more or less deeply covered with leaves, sticks, and organic debris. The other animal forms common in the ponds are such as will be found in very many other representative puddles. About twelve species of Cladocera, fifty rotifers, about a hundred protozoans, ten or twelve aquatic oligochaetes, besides very many insect larvae also inhabit these ponds.

Several environmental factors are of some detailed significance, perhaps the most vital of which is the water condition. The oxygen content seems to have little direct relation to the life processes, as the animal carries on its existence with seemingly equal ease in the clearest, freshest water, containing a high percentage of oxygen or in water heavily laden with carbon dioxide. The pond water tho constantly kept in motion by a steady stream running thru it, was often, especially near the bottom, very thick and muddy. Sometimes thoroughly clogged with algal masses so that

many parts were dark, it also supported an extraordinarily large population of animal species. Owing to a lack of balance, a number of times, in the aquarium jars, the water became very stale so that there was a great amount of bacterial growth and much of the algae dies. Such conditions were, of course, fatal to a great deal of the animal life and in time would do away with those of the flatworm type also. These, however, seemed to withstand such adverse conditions longer than most of the others. The water temperature varies within very wide limits without causing any great difference in life processes except, perhaps, in the case of the reproductive organs. The summer temperature is high and when standing in a sunny window, the aquarium jars were often warm. Here the animals thrived, being more active in the warmer water. On the other hand, the reproductive season comes during the early winter months and that it is in the coldest months that the young generation starts its life independently is probably to be correlated with the low temperature. Thus the vegetative activity seems greater in warm conditions while the reproductive organs function alone during the winter. HOwever, the life-cycle seems to be completed very soon after the eggs are laid, the individuals not existing thru two seasons. This may be due solely to the depletion of organic strength or, as seems possible, to the fact that the severest and prolonged cold comes at a time when the animals are weakened and unable to withstand such rigorous changes. The r eaction

to light is positive but neither precise nor immediate. When placed in watch glasses of water, lighted from one side, the individuals will always find their way to the lighted part after some time has elapsed. This was also true in large aquaria, but not as constant, due to influence of other factors.

The feeding habits seemto be the result of the surrounding conditions. Altho active and much of the time living in open water, these animals do not attack living forms. Live, hard-shelled Cladocera and rotifers would be difficult for such soft, unarmed forms to manage, but even the smallest protozoans appear to be safe from their depredations. Repeatedly, upon encountering a most defenseless prototoan, the rhabdocoel will glide over it and leave it unharmed. However, the whole attitude is changed when the prey is dead. Very often the dead shells of small crustaceans, some of them many times the size of the rhabdocoels, are found entirely covered by an active hungry mass, eagerly devouring every bit of edible portion. It is quite impossible to dislodge even a single individual without crushing or injuring it, so tenacious is their hold. Figure 3 shows an empty shell of a Cyclops being cleaned out thoroughly by a few individuals. As they worked, it was possible to see how industrious and intense was the habit and manner of finding every particle of edible material. They remained within the shell for more than an hour, constantly at work, until it was completely emptied of all soft material and ready to fall apart. The

animals themselves were by that time fully gorged and showed the digestive cavity dark and large, obscuring even the pharynx rosette. Ostracod shells seem easy of access and are very often cleaned out in this same manner. Dear Protozoa, also other soft bits of animal debris, are eagerly attacked and devoured and it is probably in search of such particles which may be caught in the masses of algae or have reached the upper layer of soft bottom mud that the individuals are seen in large numbers finding their way hither and thither in the deeper portions. This may also explain the fact that water, dark with masses of organic debris, forms good feeding ground, so that instead of being an unendurable condition, it is one in which there is possible greater vegetative activity. The role of scavenger is thus played by these small forms and their place in the balance of animal life must be an important one. Hardly to be considered as enemies of even a single individual, they are merely one of the types without which other more aggressive species could not exist.

It seems probable that so unarmed and defenseless a creature as this has a number of enemies, but these are evidently almost a negligible quantity. From an enemy like the fish, which takes in large amounts of water, the tiny rhabdocoel has no escape and no method of defense and numbers must thus become the food of large forms. Others will stray into the jaws of some animal along with the water, e.g., the crayfish, but the smaller crustaceans seem to make little headway in an attempt to kill and eat these dainty

morsels. Ostracods have a habit of attacking a resting individual and by means of strong appendages tearing a hole in the skin. It takes a good deal of persistence to accomplish this, however, as the rhabdocoel will either draw up into a compact ball hard to take hold of or will swim away, scraping off its tormentor in some mass of algae. Many, of course, must meet their death caught in some maze of filament or mass of loose mud but in open water they seem to be safe and able to swim quickly away from any danger. It may be, of course, that the taste is not delightful to some forms or the presence of dermal rhabdites may make them unfit for food. In some way, they seem to be able to live a life singularly free from attack and they mingle in the most courageous manner with many species of larger forms, tho for the most part lurking in some secluded part of the deeper water and coming out to the light only occasionally.

They move very gracefully with but little muscular contraction. The coat of cilia serves as an efficient organ of locomotion and the result is a very even gliding, lacking entirely the twisting and turning so characteristic of other types. In pushing thru small openings or entanglements, there is more or less muscular contraction but otherwise the cilia are able to propel the body unaided.

In case of slight injury, there must be some amount of regeneration possible, but there is little evidence of this. Among thousands of individuals examined, none were found in the process

of healing wounds or regenerating lost parts. This fact is conspicuous in comparison with other species where scars and wounds of one sort or another are common. With the above may be correlated the fact that no asexual budding has been discovered. It would appear, also, that a form of such complexity does not possess the power of unlimited regeneration but a condition of entire lack seems improbable. Further study will doubtless reveal some possibility along this line.

Family PLANARIIDAE

The Planariidae in number of species is more fully represented in the inland states than any other family of the Turbellaria. Seven species have been identified, five of which are new. Of these, *Planaria maculata* Leidy 1848 is, of course, the most common, occurring in abundance in nearly all rocky streams and in many quiet ponds. Others appear more rarely but over such widely separated areas as to suggest that they exist with much greater frequency, and in larger numbers than is generally supposed. One of the species with such a wide-spread habitat is that mentioned below.

Planaria velata Stringer 1909

This has been taken from two very different localities, one a temporary puddle at Urbana, Illinois, the other a spring at Homer, Minnesota. At the former place, the water was black and muddy with only a minimum amount of algal growth, the specimens coming from the bottom mud, with the loose silt, leaves, and sticks dragged up with a dip net. The conditions in the latter instance were almost the opposite. The spring was of warm water flowing into the Mississippi and forming a little cove where there were almost summer conditions even during the coldest weather. All of these collections were made in February and March. Here a large number of species flourished. The plant forms and Protozoa were especially luxuriant so that there was an ample supply of food for a well populated community of microscopic forms. The list

contained several rhabdocoels which were present in great abundance, and at least two planarians. One of these, Planaria velata, was conspicuous among the other forms because of its dark brown color and lines of fragmentation. There was some characteristic variation but most of the specimens were quite dark. Those few which did show a light gray were the small regenerating individuals. The color is due, as Miss STringer says, to a yellowish-brown pigment which causes the general dark tinge, but which under a lens is surprisingly pale and clear against the almosttransparent groundwork. This pigment is arranged in very small spots, either round or irregular in shape, and lying in rows. These rowa are placed very evenly, close together, and follow the same windings. In general, they run longitudinally, but every projection of any part, every indentation, every wound, causes a drawing together, or else a cutting in two of the rowa around it. Moreover, thruout the mid-dorsal region, there is a contraction of both rows and spots which will explain the heavier color of the upper side. The pigment spots within the rowa vary in their relation to each other. They may be large and close together or far apart; they may be evenly separated or not; or they may be small, scattered or collected in groups. Under all conditions, however, there is a fine line of connection from one spot to the next. This is sometimes hardly more than a suggestion of pigment while in some places the connecting thread is knobbed and heavy. These color masses are all situated in the deeper portions of the epithelial

cells.

The smooth color was often interrupted by light gray lines running in different directions across the body. In some specimens, these could be seen as grooves or furrows running into more or less conspicuous notches at the edge of the body. It is along these lines that later the splitting into fragments occurs. Often more than one or two lines could be distinguished at once and very probably in some specimens there might have been several since Miss Stringer reports as many as thirteen fragments from a single individual.

That the lines of division appear so early in the pigmentation and skin is noteworthy, since in some species the internal divisions are laid down before the external are very prominent.

<u>Planaria maculata minor</u> nov. var.

In the many collections which have been made in the past, <u>Planaria maculata</u> has appeared often and in large quantities. The situations in which it lives are necessarily varied, and often in many respects they are entirely opposite to those where it has been found previously. Then, too, the immediate make-up of a pond or stream generally changes somewhat within the length of each season, and much of this change is detrimental. Another point to be considered is the lack of protective details, for, from many of its enemies it has no escape. A summary of these conditions will explain the very apparent differences in structure among the individuals of even a single pond. The variations are mainly

those of size, shape, and color, and since a very large percentage have suffered mutilation, there are always many specimens which show parts in some stage of regeneration. Thus structures may be altered within wide limits and the animal still be fairly typical. For these reasons, when many planarians from the Rock river showed small eyes, the fact was hardly noticed, and it was not until large numbers revealed the same character that special attention was given to it. Several hundred specimens were taken from different places along the river, all with this same distinguishing mark. Other collections in the Mississippi river, at Homer, Minnesota, at Fairport, Iowa, and also in the adjoining ponds showed the same detail. In most respects, the characters are clearly those of <u>Planaria maculata</u>. The variations are of the same general nature, the habitat the same, the conspicuous difference being only in the size of the eyes and in the surrounding pigment. Exact measurements were taken of the eyes in a few specimens from every collection and approximate comparisons made for several thousand more. There were always to be found a number of individuals with clear white regions, lacking entirely any eye pigment, and there were always individuals with eyes at some stage of regeneration. These were never taken into account in the general results. The dark pigmented portion was measured for both length and width with some note as to the shape. From several hundred specimens measured, the average varies between 0.113 mm. and 0.167 mm. in length and 0.008 mm. and 0.031 mm. in width,

In general, the eyes are a fairly regular kidney-shape but the percentage of difference between the two eyes of the individual is high. This, however, is true for all planarians. These measurements were very nearly one-half those of an average Planaria maculata. The shape is a little more solid, bot inclined to be a crescent but always broader in proportion to the length. The position of the eye is also significant. In the river type, the eyes are always very much nearer the median line than in the common form. They also lie almost in the edge of the middle pigmented stripe of epithelium. This situation makes their relation to the whole of the unpigmented region somewhat different from that of the common type. That is, lateral to the eye-pigment, there is a very large irregular clear space. This is about five or six times the width of the eye itself, and is striking in its transparency. In the common type, on the other hand, the clear region, altho varying to some degree and irregular in outline, fits closely to the eye-pigment leaving only a wide margin of transparent integument.

This special character seems to be constant for the individuals found in the Mississippi river or its immediate vicinity. Whether it is only an environmental change due to some immediate biologic condition or whether it is developmental, remains to be seen.

Family CATENULIDAE

The family Catenulidae was created by vonGraff in 1905 to contain five genera, two of which, Stenostomum O. Schn. and Alaurina W. Busch, had, up to that time, been grouped under the family name Stenostomidea, and a third, Microstomum O. Schn. had belonged to the Microstomida. To these three, he added two others, Rhynchoscolex Leidy and the old Catenula Anton Duges, which had hitherto been in a group by itself, seemingly unrelated. He took the name of the new family from the oldest genus. Two years later, in 1907, Alex. Luther added the genus Liphorhynchus, a species with very heavy pre-oral furrow. Then, on the basis of the paired excretory tubules, and in agreement with the researches of Vejdovsky (1882), Sekira (1888) and himself, he removed Microstomum and Alauria, putting them together to form the Microstominae, a sub-family of the Macrostomidae. Another change came in 1908, when vonGraff substituted the generic name Fuhrmannia for Lophorhynchus, since the latter was already in use. The list of genera belonging to the Catenulidae was thus 1) Catenula, 2) Fuhrmannia, 3) Stenostomum, 4) Rhynchoscolex, and this classification now stands.

This family is the simplect of the rhabdocoel group. It is characterized by the lack of an anterior prolongation of the intestinal cavity, and by the possession of a single protonephridium. The testes and ovary are always unpaired, tho in general they are not to be found, since periods of sexual maturity are

rare. The common method of reproduction is by budding and chains of two, four, or six zooids are much more frequent than single individuals. Without eyes or rhabdites, almost entirely lacking in color, these forms are most inconspicuous. With good reason, have they been likened to large protozoans, and superficially, at least, seem to be entirely without specialized structure, always small, few in number, compared with other types they are easily overlooked.

Of the four genera, three have been reported from this country. One species of Catenula and two of Rhynchoscolex were collected in small numbers around Philadelphia many years ago. They are probably present in other places in the eastern states, but have not yet been found here. The genus Stenostomum is quite different in its distribution. Several species have been described from very separated localities and the genus as a whole seems to have a rather wide-spread occurrence. It w as first described by O. Schmidt (1888), who recognized the characters which separate it from Microstomum. He named two species and during the next thirty years eight others were added by different investigators. Up to 1905, the genus name was Stenostoma, then it was changed to Stenostomum, following the new nomenclature. In the United States, two European species have been identified, while four new ones have been added. This is the most important genus of the family, since it is by far the largest both in number of species and number of individuals. Altogether, there are sixteen species,

one being a salt-water form. Then, too, the feeding habits makes it seem to warrant an economic importance.

The most noticeable details of structure are the rather large sensory pits on either side oft he head. These are unique and extraordinary in themselves and probably take the place of the statocyst, eyes, and sensory organs of other types. The blunt, somewhat stiff anterior end and the protruding mouth region give a special shape and appearance to the head. The comparatively large intestinal cavity, filling so nearly the integumental sac is another conspicuous character. Altogether, these forms are worthy of more than ordinary interest.

Of the sixteen species which make up the genus, the oldest, Stenostomum leucops O. Schm. (1848) has had the most attention. The original description was full and exact. Almost nothing more was done with it until H. N. Ott in 1892 made a careful and complete study of the histology of all the body systems, bringing out a number of details of value for c omparative work with other families. Since this form is most primitive and evidently nearest the ancestral type, all characters of structure are of especial interest. In an experimental way, several authors have made exhaustive researches. C. M. Child during 1901-2 and 1903 published a series of five papers dealing with the development of the zooids and regulation of fission using both t his species and Stenostomum grande. His results explain, at least to some degree, some of the life-habits and variations always to be

noticed. Since the asexual reproduction is the general method, individuals in all stages of regeneration and development are to be found together. One or two of his general conclusions throw light on the laws which govern these common processes. Perhaps the most important are the following: When a zooid separates from the chain thru injury, "complete destruction of younger parts by older, may occur, but not older parts by younger." Again, if the separation from the parent is very early, the anterior portion of the young individual develops a brain regardless of its former relationships. These two facts will account for many of the half-changed shapes and conditions present in smaller specimens.
Ritter and Congdon (1900) have also used this convenient form as the basis of a series of experiments having to do with fission induced artificially or inhibited in some manner. These authors emphasized the migration of the brain ganglion and also certain special laws of regeneration which seem to hold. Child does not agree in his findings and brings forth rather exhaustive data to prove the truth of his conclusions.

The use to which this species has been put is due partly to the simplicity of structure, and consequent simplicity of reaction, partly to convenient size, and partly to the abundant supply of individuals. The distribution is very much wider than was earlier supposed. Silliman (1885) was the first to find it in the United States. He discovered it in large numbers in certain ponds in the east. The knowledge of its occurrence in other places

came slowly. Every few years it was reported from some new locality, but not until within the last fifteen years have the collections been adequate enough to prove its presence common thruout the country. Now it is known to be living in three-fourths of all the ponds wherever there is other animal or plant life. During the winter, under the ice it seems to carry on a successful existence and can generally be found at any time. Of the whole group of rhabdocoels, this species is the most common, in fact almost cosmopolitan, and it is likely that future collections will prove it entirely so.

In the way of biologic relationships, some few new observations may be of value. One character which makes possible the very general habitat is the ability to exist under varying conditions. Stenostomum leucops is able to live in situations where the oxygen content is extremely low and where often the amount of carbon dioxide present is so large as to kill other members of this group. This explains the fact that it may be present in small puddles and ponds where there is almost no plant life, or in places where few animal types exist. Often, too, in cases where the water is thick with bacterial growth and disintegrating material of all sorts, the Stenostomum is able to live long after the conditions seem entirely unfit. That they are sensitive to presence or absence of oxygen and carbon dioxide is shown when specimens are placed in water where part of it is cleared and fresher than the rest. They invariably find the freshest

parts, even tho the difference be very slight, and are always to be found in the clearer portions of an aquarium.

The reaction to light is negative, tho not very prompt or definite. That is, the specimens are always on the side of the aquarium away from the light but it takes some time for them to find the position and many seem to prefer not the very darkest places. It may perhaps be said that both the brightest and darkest portions are unfavorable, and that a merely subdued light is to be preferred.

The reactions are not at all precise or prompt and the animals seem to be sensitive to general influences rather than to direct stimuli. Heat and cold in a general way seem to have almost no appreciable effect. Small weak individuals are found as well in summer as in winter, large plump specimens in cold as well as in warm water, and, too, the period of sexual maturity is not so exactly dependent upon change in season and consequent change in temperature as in most rhabdocoels. It is true that in winter, ponds where a small stream of water raises the temperature, the numbers which find the warmer parts are very large, but other conditions very probably hold here, as in such places there will be more food and often since the water was fresher, more oxygen. As a whole, the response to any ordinary stimulus is never strong. If the stimulus is so intense as to cause a decided reaction, it is generally then of such a nature as to be injurious or perhaps to kill.

The food relationships are more complex than appears at first. How many enemies there may be is hard to ascertain. That the Stenostomum becomes the food of other species is not clear since their bodies are entirely of soft parts easily disintegrated. They seem not to be hunted down by other forms to any great extent, except in the case of some few fishes which would anyway easily take them along with other microscopic species. When, however, the body structure is disintegrating, the protoplasmic content within the rhabdite-bearing integument is good food for almost any form. They can hardly be said to form any conspicuous part of the food of any animal. The food they eat is of much more interest and importance. To some extent they are scavengers, eating the disintegrating organic material so plentiful in the surface of the bottom-mud, or entangled in masses of filamentous algae. They are voracious hunters and can nearly always be found working their way, truly worm-like, thru the soft silt, systematically seeking out every bit of available nutrient material. They also evidently swallow much indigestible matter, as after a period of feeding in such a situation, the intestine will be almost black and later this residue will be extruded thru the mouth, sometimes a little at a time, and often in quite large masses. That this common form plays a large part in helping to keep clear the bottom water is very evident. The small algal swarm spores, volvox, euglena, and the like, to some extent, are eaten but are probably more or less unpalatable. The food which is the most

conspicuous, tho hardly the most common, is made up of the larger animal types, such as ostracods, glochidia, encrusted protozoans, and the like. Stenostomum leucops especially seems to have a liking for the largest possible morsels, preferring those with a hard shell. Difflugia is, perhaps, the most common form found lodged in the intestine and is present in even rather small-sized individuals. During a few days, five different species have been seen within the digestive cavity of specimens from a single pond. The naked protoplasm of the animal part, even tho entirely drawn into its shell, is easily digested out and the comparatively smooth spherical exterior makes a mass easily extruded. The size is also convenient, not so large but that even the contracted zone of fission may allow it to pass thru to the posterior zooids. In the same way, other small smooth forms seem especially desired. One example will show the tendency in this direction. An individual was noticed swinging around normally except that the movement was a little slow. The shape, however, was conspicuous as the animal seemedto be a tiny cross, very clear-cut and definite. Under the microscope, the extra structure proved to be a good-sized ostracod lying in the intestinal cavity at right-angles to the length of the body and by its bulk causing the body-wall to be pushed out on the two sides till the protruded part was equal to the other divisions. The animal seemed to suffer no serious inconvenience tho the integument and intestinal wall were stretched to the breaking point. Evidences of such unappropriate food are quite

common. Any rounded bard-shelled animal seeme acceptable either in part or entire, and the Stenostomum will often attempt particles entirely too large t o be managed. Spiny, rough, or even slightly irregular bits are almost never touched altho they may be small and easily captured. That very large bodies can be passed thru the slender pharynx is evident, if the more or less constant dilation and contraction is noticed. When the intestinal valve is closed the the long pharynx is collapsed, it appears as only a narrow line running back from the buccal indentation. At various intervals, often rather suddenly, the mouth is opened, very wide, so that its diameter is nearly that of the body, then immediately the pharynx is dilated almost to a sphere, displacing the walls of the surrounding region and giving almost a globular shape to the head. It is this elasticity of the walls and enveloping parenchyma as well as the heavy muscular contraction which gives the possibility of extended variation both in size and shape. The intestinal opening is also capable of enormous distention. The extreme flexibility and lack of cell intimacy have been mentioned as one of the important characters of t he phylum and the development of such a character seems to have reached its height in this species, a fact which to some extent explains the variation in the food taken.

The types just mentioned as food preferred by rhabdocoels also help to make that of many of the fishes. Altho it seems hardly possible that individuals so minute could make an

appreciable difference with the food supply of animals like even the smallest fish, yet they are to be considered as forming a part of the life-struggle of such economic species. To what extent they offset this by themselves being devoured can only be estimated, but it is probable that they do more harm than good, since all the protoplasm upon which they feed is of definite food value, while them, themselves, are too few to be taken into account as a supply.

Another striking detail of appearance is the difference in shape, size, and number of zooids among individuals not only of several ponds but those from one part of a single pond. This difference in appearance is the result of the formation of zooid chains, and all stages of growth are to be found present at almost any given time. In localities where conditions of food, oxygen, and temperature are ideal or nearly so, the chains of zooids form rapidly, and the segments cut off are small and blunt at first, tho they elongate very soon. Child (1902) very thoroughly worked out the history of the regeneration and stages thru which the segments pass before they are themselves ready to divide. It is commonly known that almost immediately upon being separated, the segments invariably attach themselves to some convenient substratum. The subsequent shape, Child says, is the result of this habit, and the "elongation of the body can be prevented by preventing the animals from attaching themselves". His final conclusion is of especial interest. "Due to attachment of animals by the tail,

and to mechanical tension caused by ciliary action, the form of vegetating pieces is changed; it is a mechanical phenomenon and not the effect of stimuli". The truncated, anterior zooid after the cutting off of the others, is a conspicuous shape very frequently met with. It can never attach itself and so rather aimlessly swims about stiff and awkward until the rounded short posterior end begins to become normal. In no other type is the shape so entirely dependent upon physiological condition or relative age. The number of zooids for this species is generally two, altho longer chains are often to be seen. This is due to the fact that fission planes are rarely interpolated between others and that the first division takes place before a second zone of division begins. This is quite the opposite condition from that in the Microstomum, where when fission planes are laid down at all, they very closely follow each other. It may be said that in Stenostomum the asexual budding is not to be correlated with any season or with environmental conditions, since it is a constant process, but that the rapidity of the growth of zooids, i.e., the number of generations developed, is dependent upon these surroundings.

Most often in ponds where Stenostomum leucops is present, in larger or smaller numbers, there may be also several different species of rhabdocoels, but generally no other members of this genus are to be found. In several of the ponds at Fairport, Iowa, however, Stenostomum tenuicauda was also present and was in this instance the more frequent with very nearly the same life-

habits and the same environment. The two species existed side by side. But there was a great difference in their rapidity of movement. S. leucops is much more regular and quiet, holds more constantly to course, while S. tenuicauda shows a tendency toward a greater amount of action. In appearance, too, they differed decidedly, while the former is slightly opaque, the latter is quite clear and transparent, slightly yellowish in tinge. The slender tail region is also conspicuous when taken together with the blunt and heavier condition in Stenostomum leucops.

Stenostomum giganteum nov. spec.

This species was collected in large numbers in a pond with sandy bottom and clear water. The water was very warm at the surface and cold a few inches down. The drainage area was small, with no direct inlet, so that under all ordinary conditions very little outside water came in and since most of the water was seepage, there was no chance for any number of species to be washed in. There was a small rivulet carrying off some surplus, but for the most part there was no current and in fact not even disturbance of wind. The conditions were very nearly those of a balanced aquarium. These facts probably account for the scant number of species, and also for the large number of individuals of the few which had in some manner found their way to a place in so many ways so ideal. The comparative shallowness, with sandy surrounding area prevented any silt from being deposited, then, too, the amount of disintegrating organic matter was minimum. The plant

life was profuse, enough to take care of all the carbon dioxide generated, so that the water was always clear and fresh. The animal life was composed of a few fish, mostly Amia, a few stray turtles, microscopic forms, a small crustacean, protozoans, and many rhabdocoels. The lack of disturbance or change and the constancy of inter-relationships of various species precluded great differences in the general fauna and flora and made possible the persistence of the same types and a continuation of the same relative conditions. The situation in the present instance was, perhaps, slightly different from that of other years, since by a break in the shore line the river had swept down thru the pond carrying away the whole thing. As a result, all the pond life was new, at least only that left when the water receded. The rhabdocoels were floated out in numbers from masses of Chara pulled up from the bottom where the water was eighteen inches deep, but they were not to be found in any of the masses of Spirogyra taken only a few feet away. The coarser leaves of the Chara evidently harbored more protozoans, more organic debris or other sorts, and thus furnished a larger supply of food, but the oxygen in that region must have been very much less. No specimens were taken at the surface, they were always down a few inches where the water was quite cool. Stenostomum leucops was present in only small numbers and Stenostomum gigantea was very numerous. The food seemed to be almost entirely protozoans and small crustaceans, the size making it possible to swallow easily a number of species.

The movements were invariably slow and the twistings and turnings so characteristic of Stenostomum leucops were very very nearly lacking. Most of the specimens were made up of two zooids, and not a single chain of more than that was found. They were negatively heliotropic. Their length of life has not been ascertained, as they were found only during the summer months. A number of collections were made during January, thru eighteen inches of ice but the very shallow water below this thickness showed only a very few crustaceans. Dead fish were seen and it was apparent that very little oxygen was left in this bottom layer.

The relations with other forms seemed quite simple, their only enemy was probably the fish, and the whole life condition was without great struggle.

Among the other animal types to be seen in the collections, this species was very conspicuous, even to the naked eye. It was the largest of the nearly microscopic forms and moved quite enough to be easily distinguished. As has been mentioned, ninety percent of the specimens were composed of two zooids, and such individuals averaged in length from one to two millimeters. The two parts were not quite equal, the posterior generally being a little the longer, so that the measurements would average about 0.7 to 0.9 mm. for the anterior segment and 0.8 to 1.0mm. for the posterior segment. The single individuals were, as a rule, those which had lately split and were of ordinary condition. They were almost always a little over one millimeter, but never reached the

length of 2 mm. The width and depth were very nearly the same except in the tail region and in the very anterior end. This diameter was from one-fifth to one-quarter the entire length of a double individual or in many instances where a separate segment was measured, was as much as one-third the length. On the whole, this species seemed about twice as large as the common Stenostomum leucops.

In shape, these specimens were quite different from other members of the genus. They were not so slender, but seemed more stubby and rod-like. The ratio of diameter to length was 1 to 4 or 5, rather than 1 to 7 or 10. Not so agile or flexible, they were stiff little cylinders, tapering off bluntly to a short tip. That is, from about the middle of the posterior zooid to a point just behind the mouth, the diameter is always the same (except at the fission plane). The region around the mouth is somewhat protruded as a sort of circular lip which on the posterior ventral portion is somewhat extended, making a bulge or knob-like enlargement at that point. The dorsal anterior part is only slightly inflated and slopes up to the anterior proboscis or lappet-like front end. This is a triangular flat portion extending back behind the ciliated pits. The greatest width of this triangle is nearly equal to that of the body in general but the thickness is not more than one-half the body depth, so that the mouth enlargement is accentuated. The shape of these forms generally

depands to a great extent on the amount of contraction or expansion but here the rather unwieldy body is never to a large extent altered. That is, the animal is flexible and capable of contracting within somewhat narrow limits. The most contractile portion is, of course, just behind the mouth region where the extreme flexibility of the pharynx demands heavy muscular action, and this part is much more thoroly developed than that of any other species. Such a condition can be correlated with the heavier kind of food. The regions of greatest contraction show clearly in the preserved material, where the anterior t ip and pharyngeal regions are drawn back into the body integument.

The color appears quite white. Since the body is heavier and thicker than most forms, it is opaque and not at all transparent. The heavier integument and thicker layer of parenchyma obscure the intestinal contents and also the intestine itself, so that there is no chance for any color to shine thru. Against the dark background of water, these individuals stand out strikingly.

The integument is, of course, a one-celled layer, a little heavier in proportion than that of other species. It is not so transparent as might be expected, due to the rather solid outside cell walls, but in most respects is not very different from the general type. The thickness varies with contraction. In life, it is about 10 , in mounted sections it is close to 17.5 over all the body except the anterior and posterior ends,

where it is from 20 to 25 . That the cohesion of the cells is slight is evident in such prepared material where many of the cells are practically pushed out or even completely dislodged from their original position in the epithelium. When the whole structure is thus crowded, the cells dove-tail into each other to some extent. They are then high columnar, but more or less irregular, almost trapezoidal, often so as to fit compactly. The portion containing the nucleus is the larger and with few exceptions is the inner part. The nuclei are large and stain heavily so that they form the most conspicuous part of the integument. In sections, they stand out against the very fine delicate cytoplasm. The cilia are veryfine and long, from 16 to 20 . They are of about the same size and are distributed evenly over all the body. They move in waves from anterior to posterior as a general rule. The cilia lining the sensory pits and mouth indentation are longer than the others and very even. The ventral side is not so much differentiated as in most species and the cilia are little different from those on the dorsal side. At one point near the posterior end, however, where the animal habitually attaches itself, the epithelial cells are a little heavier and the cilia show a tendency to be short and large. Another detail not so conspicuous is the presence of very small, clear rhabdites; where the integument is expanded they lie flat, parallel to the surface but scattered and more or less irregularly placed with regard to each other. Under heavy contraction, when the cells are narrow and deep, the rhabdites are

perpendicular to the surface, arranged evenly as a layer on the outermost surface, just beneath the cilia. They are even, smooth little rods with blunt ends and are all of the same size, and occur over the whole surface of the body. The influence of killing and fixing agents often slightly swells them to transparent knob-like bodies.

The integument is very closely related to the muscular system which lies just beneath it. As Ott (1892) has pointed out, the inside, next the epithelium, is composed of circular strands while that inside toward the parenchyma is longitudinal. The circular muscle cells are many and make a single row of almost round cells extending the length of the body. This row of cells is interrupted at the fission plane and in the region of the ciliated pits. The several individual strands are often 20 apart, often side by side. The cytoplasm is granular and stains heavily. The longitudinal cells are very slender strands with the nuclei showing as tiny enlargements along at different points. They are not many in number and are scattered. Very few run directly longitudinally, most being slightly oblique or extending from one portion of the epithelium to the intestine or t o some other part. The layers around the pharynx and mouth have the cells lying much closer together and on the whole they are longer. Around the wall of the intestine, the circular strands and also the longitudinal are almost embedded among the digestive cells. They show somewhat scattered heavily stained between the outer

ends of the light large cells which make up the assimilative layer. When the intestine is filled and the small amount of parenchyma pushed away, these muscle strands are close to those of the body wall. The most striking characteristic of this system is the extremely small number of strands or fibers thruout the whole structure. There is much less true muscular contraction than in almost any other family of this group and a great part of the movement of cells is due to changes in physiological condition.

The parenchyma is extremely vacuolate and the cells are very delicate. Most of the support given the different organs and also the stiffness of the body as a whole is due to the turgidity of these few parenchyme calls and to the watery protoplasm which fills the vacuoles. As Ott finds, for Stenostomum leucops, the space between the intestine and body wall contains very few cells and the only material to be displaced under varying conditions is the body fluid. The largest mass of parenchyma is that just posterior to the brain and surrounding the anterior portion of the pharynx. In prepared sections, this shows as a very irregular network with very few nuclei, many of these connecting strands are broken and the cell bodies torn. The body of the cell is rather small but varies somewhat. The nucleus is round, stains deeply, showing large granules. There are generally five or eight longer or shorter threads or processes extending in all directions and forming a connection between neighboring parts. The simplicity of this system is one of the characters of the genus and this

species seems to have fewer parenchymatal cells than any other species.

The digestive tract is the most noticeable part of the anatomy. The mouth with its enormous stomadaeal indentation is conspicuous. The comparative size of this hollow epithelial-lined portion is suggestive. The cilia here are longer than in other parts of the integument. The mouth is really situated at the inner end and is the point where the true ectoderm ends. It is, of course, flexible and is controlled by a few strands of muscles. In the main, however, it opens or closes as a result of the expansion or contraction of the pharynx. The pharynx, when expanded to its limit, reaches the body wall and pushes that out making the whole of that region appear round. This amount of enlargement is greater than in any of the other common species. In other respects it resembles them, as in the presence of gland cells connected with the outer wall and the lining cilia. The entrance to the intestine is not as sharply marked off as in some species and this opening is not so precisely governed as the mouth. A very few muscle cells surround it but they are not strong enough to act as a sphincter so that the closure is made by the pharynx altho there is a very distinct line of division between the pharyngeal cells and those of the intestine. The intestinal wall is perhaps the most specialized part of the body structure; altho made up of only one thick layer of cells it shows a surprising amount of variation. When not inflated by a large amount of food, it is

thrown up into a series of rather regular folds. The outer portions of the cells under certain physiological conditions shows a protoplasm very finely granular--almost clear. It is these portions which undergo most of the pressure and stress when the intestinal shape varies and they generally are much narrower and smaller than the inner half of the wall. This inner border is often very irregular, some cells being pushed far out into the intestinal cavity. This is caused either by the crowding of the outer margin of the wall or by the internal pressure of the cytoplasm. For, as the assimilation process progresses, the protoplasmic portions of each cell require relatively large amounts of food material, generally in the shape of oil globules. Sometimes the contained mass is so large as to occupy the major portion of the cell, and gives a very characteristic appearance. Other cells so situated that only a narrow section of the intestinal surface is free may have no extra material and be small and shrunken. Thus in most respects the intestina is an organ very like that of other species.

By slightly flattening the animal, the simple excretory tubule can be seen contracting slowly and irregularly. It is large enough to be clearly distinguishable and its course can be followed from the posterior part forward to the anterior loop and then back to the external opening. The diameter is about that of the thickness of the integument and the white color makes it stand out against the dorsal wall of the intestine.

The reproductive organs have not been studied since the period of maturity occurs rather seldom. The asexual budding is common. All of the specimens taken were either in the process of forming zooid chains or had evidently recently separated. Externally, the first or median fission plane was the only one completely enough developed to be noticeable so that almost all the specimens appeared to be formed of only two parts. The reason for this is the precocial or rapid development of the organs in the first budding zone, so that the separation takes place before the organs of the next zone have become visible from the exterior. Sections of such a zooid chain show the relative development of the several parts. The situation is briefly this: The brain ganglion on the dorsal side and the buccal indentation on the ventral side of the digestive tract become about half-formed before the integument and parenchyma begin to narrow in at all. By the time this pushing-off process is nearly complete, the mouth has broken thru, the sensory pits are formed, and the last connection is by means of the intestinal cavity which is continuous thru the proboscis-like anterior end of the posterior zooid. In this species, such a connection remains intact for a longer time than in most others and it is broken off only just before the two individuals separate. Generally, in both individuals of such development, a histological examination will show the beginnings of another fission zone in the anlege of a new pharynx and another brain ganglion. The fission plane is quite exact and sharply cuts the parts, while

in some forms the constriction is gradual, so that the adjacent parts do not lie very close together.

Comparing this species with others of the genus, it seems very blunt and solid by the side of the more slender, agile types. The proportion of diameter to length is very much greater than is common.

<u>Stenostomum</u> <u>glandifera</u> nov. spec.

The form given here was present in several ponds in all of which the bottom was muddy and covered with a fine layer of silt. The plant and animal species varied, but in all cases the environmental conditions were much the same. Except in one pond, the sun and wind had much effect upon the t emperature and quietness of the water. <u>Stenostomum</u> <u>leucops</u> was also present with some degree of frequency. There was always either some filamentous alga or Chara, and the living surroundings were ideal for all types of microscopic animals. Most of the food material seems to be taken from the silt and very little from other sources, that is, this species is entirely a scavenger in its habits. Tho swimming free when disturbed, and often at other times, quietly gliding around, it pays no attention to any food material and only feeds when hunting thru the thick bottom debris. This accounts for the fact that the intestine is always very dark in color. But, in general the life-habits are very similar to those of related forms.

In a study of the anatomical details, a few characters are significant. The average size is about one millimeter, altho,

of course, there is the same variation as in the whole genus. The shape, however, is more characteristic and definite. This is a very slender form with little difference in diameter. The relative proportion of length to width and depth is about one to eight, which is quite different from some others where it is one to five or six. The anterior tip in front of the mouth is much shorter than in most species, a condition which gives the head a much shorter, blunter aspect. The shape of this end is also less pointed than is often found. The posterior portion also is short, that is, the diameter of the body remains the same to a point about one-fifth the length of the body from the end. Then, the sloping off to the posterior tip is very rapid and this end is nearly as rounded as the anterior end. The body, tho so regular is not at all rigid and bends easily. The color is light, except in the intestinal region which generally shows up quite dark, making a decided contrast between the anterior quarter where the head and pharyngeal portion is nearly transparent and the heavy body part.

The integument is very thin, delicate, and transparent, which allows the internal condition to be easily seen. The cilia are short and very evenly distributed thruout. They are only slightly longer in the mouth region. The rhabdites correspond closely with those of other forms, being very small, regular rods scattered thruout the epithelium and lying parallel to the surface. Several are often grouped, lying side by side, but many are single.

The parenchyma is exceedingly transparent and is concentrated in the head region anterior to the digestive cavity. The posterior triangle between the intestine and the tip is very small and generally almost obliterated. The layer enveloping the intestine is so thin as to be very nearly lacking, its presence being demonstrated only at the fission planes where it forms a mass gradually increasing and pinching off the digestive cavity.

The most noticeable character of morphology is the digestive tract. The mouth expands into a somewhat irregular round opening, but does not contract to such a small cavity as in some species. The mouth indentation is a deep funnel rather heavily muscular but not so flexible as in those types which are in the habit of swallowing large masses of food material at a time. This funnel leads to the pharyngeal cavity which is rather long and narrow. The wall here is very transparent and the outside cells small and almost invisible. The connection with the intestinal portions is very sharply marked by a deep constriction. Except when the opening is somewhat expanded, the pharynx appears pinched offcompletely. The lumen of the digestive cavity is small and fairly regular in general outline. The wall, of course, is folded more or less but the folds are of nearly the same size and follow one after the other about t he same distance apart. Within this wall,or rather very closely applied to the outer surface, and really a part of it are numerous masses of cells. These are a little longer than wide and are scattered regularly over t he whole

intestine. VonGraff (1911) figures intestinal glands for _Stenostomum tenuicauda_. These are much smaller, varying somewhat but anout one-half the size and are more numerous, showing about three times as many in each individual. They are quite flat against the surface and protrude only slightly, while those of _Stenostomum tenuicauda_ are heavier and nearly globular. These glands are undoubtedly digestive in function but their exact working has not been made out.

Other details of specific value are the special sensory organs. The ciliated pits on either side of the anterior lappet portion are small and shallow compared with those of _Stenostomum leucops_ or _Stenostomum tenuicauda._ They are verynear the end, half as far from the tip as the width at that point. They are not so conspicuous as in most species, as the epithelium is not thick or the cilia long so that the outlines are not sharp. The patelliform or light-refracting organs,on the contrary, are very distinct and appear as rather large, bright, almost irridiccent spots directly back of the two sensory pits and on a line with the naterior edge of the mouth. They are not exactly round, but have a slightly angular outline, showing thru the clear parenchyma, almost like two bright eyes. The size and brilliancy of these organs distinguishes them from the small and dull developments in other species.

The zooid formation is another developmental trait. The first fission plane is far posterior, cutting off about one-

third of the body length and second and third divisions are seldom found. The diameter externally is not changed until the internal parts have been nearly completed. The parenchyma acts as a protedtive cushion surrounding the partially developed brain and pharynx and at the same time confines and pushes back the intestine until only a very attenuated portion connects with the anterior zooid.

The distinctive details may be summarized as; first, slender glandular bodies occurring in the wall of the intestine; second, especially large and clear patelliform bodies together with small sensory pits; third, an extremely constricted connection between pharynx and intestine; fourth, a cushion-like mass of parenchyma protecting the anterior end of the second zooid; fifth, the very regular cylindrical shape.

Family MICROSTOMIDAE

This family name was proposed in 1907 by Alex. Luther to contain two subfamilies, the Microstominae and the Macrostominae. The former had, before this time, been a genus of the Catenulidae but the researches of Sekera (1888) and Vejdovsky (1895) and especially by himself made a new classification necessary. The latter had been a family by itself composed of three genera. The interrelation of these two subfamilies was made on the basis of the paired excretory tubules, simple pharynx, and ventral mouth. The main differentiating characters are the presence or absence of a preoral intestinal diverticulum and the habit of asexual budding possessed by the Microstominae to a surprising degree and not at all in the second group.

Microstomum caudatum Leidy 1851

The Microstominae contains two genera, one of which is found in this country, four species having been reported from one or two places in New York and Michigan. One of these, Microstomum caudatum, is present in large numbers in an artificial pond at Grinnell, Iowa. It has been taken as late as the last of November from heavy masses of Cladophora floating near the shore, and to the naked eye appears very much like Stenostomum leucops, which was also to be found in some parts of the pond. Almost all of the specimens showed three distinct fission planes, two nearly complete pharyngeal cavities and two others at a much earlier stage of development.

This was clearly <u>Microstomum caudatum</u> but in several minor points it differed from the original descriptions of that species. In size, it was about two millimeters long, the average of the whole number of specimens taken being within very narrow limits. The anterior end was not as large and round as the eastern type. It seemed slightly pointed at the apex, being very little broader than the posterior tail end. The tail part also was somewhat different from that of the original type in that it was round and blunt and not at all pointed. The whole surface was quite smooth and regular, showing almost no indentations at the lines of fission. The color was a very transparent, almost irridiscent pale yellowish-green. The intestine when empty was also surprisingly clear, showing hardly any yellow at all, blending with the surrounding parenchyma. There was the greatest difference, however, when it was more or less filled with food material, as then the color was a distinct gray giving an entirely different tinge to the body as a whole.

The epithelium is very thin and transparent, but bears extremely long cilia which are few in number, of the same size all over the body and rather heavy. The most noteworthy details of structure are the nematocysts, which are very conspicuous. They are nearly one-third as large as the pharynx and are spherical in shape. Before being discharged, they appear to have a small, sharply-tipped cone-shaped structure within, and lie parallel to the surface of the body. When the cell is set off, this thread

of the sting is shot out from the tip of the cone. These nematocysts are scattered very evenly over the body, and are about fifty or sixty in number.

The muscular system is very slightly developed and together with the parenchyma forms only a small part of the body make-up. The pharynx is deep and broad, cup-shaped, with the mouth opening very large. When closed, however, the mouth makes only a narrow slit on the ventral side, standing out sharply against the circle of the pharynx. The intestine is broad, its diameter being very little less than that of the body, and the wall well marked out and solid. It is not an even cylinder but shows a tendency to widen out at each fission plane. This brief summary emphasizes the many minor variations which may be evolved in - different environments.

Macrostomum sensitivum Silliman 1885

One individual of this species was taken from a small pond in which seven other rhabdocoels occurred in larger or smaller numbers. In most respects, it very closely agreed with Silliman's description but in regard to a few points, added details may be of value. The rhabdites which are arranged in groups of two or several, lie in large, spherical cells. In shape, these rods are long and straight, rounded at one end and somewhat pointed at the other. Generally, tho not always, they lie parallel to each other. The rhabdite-bearing cells are scattered evenly over the surface of the body and not at all gathered into tracts. In the

cytoplasm, there are a number of large, light colored globules, placed in close proximity to the rhabdites. These globules are relatively large and prominent and evidently have to do with the functioning of the cell, tho whether they are stored nutriment or are merely a by-product of the heavy metabolism is not clear.

The sensory organs are also noticeable. The eyes are very far apart, nearer the lateral margin than the middle line of the head. The sensory hairs are very clear, sharply pointed and seem often to be bent back at right angles to about the middle. This bending may be directly opposite to the position of the cilia, a fact which seems almost impossible. In general these hairs are evenly distributed, but sometimes they may be grouped in tufts of six or eight.

The digestive system as a whole varies not at all from the eastern type but the muscular power of the pharynx seems extraordinarily developed. The mouth with its boundary of heavy glandular cells may be protruded as a cone-shaped elevation which is constantly being turned from side to side. The muscularity extends back thru one-fifth the length of the intestine and is very conspicuous in the live animal.

The reproductive organs are also noteworthy. The chitinous portion of the copulatory apparatus is bent, as usual, but the whole tip is broader and heavier than in the original diagrams. The eggs develop, a number at a time and crowd forward, stretching the oviduct and filling the space between the intestine

and the body-wall. This brief summary covers the main details of variation.

Macrostomum album nov. spec.

Of the three genera which make up the family Macrostomidae, only one is represented in the eastern states. Two species, Macrostomum appendiculatum O. Fabricus and Macrostomum sensitivum have been found, as a few specimens at two or three different times. The former has also been taken at Lincoln, Nebraska, thus the distribution appears wide-spread.

Several specimens of another species have been found in the same pond with Strongylostomum. Superficially, they appear like large Stenostoma, except that they are a more opaque white and are never seen swimming free in the water but crawling over the surface of the aquarium, hunching along, as it were, one part of the body at a time. It moves slowly and unevenly, with great difficulty, by means of a muscular contractions, slight waves passing over the body very slowly. When at rest, the animal lies crouched and somewhat drawn up with the head bent a little to one side and more or less of another little bend at some other point. When in motion, the head is hardly ever held straight with the body, but is constantly moved this way and that, as tho investigating the surrounding surface.

In size, the individuals vary from 0.75 mm. to 2.10 mm. in length, the measurements taken when the animal is as extended as possible. The width was hard to ascertain because of its

great amount of variation, never being the same for any length of time. The average was 0.3 mm. to 0.7 mm. for a point about the middle of the body. The depth was nearly that of the width except in the tail region, where there was some flattening. As a whole, the animal is very nearly cylindrical. The head end is as broad as any part of the whole body, but very amenable to change, so that often it appears pointed. In a lateral view, it shows a slope to the ventral surface, making a blunt point. At about the region of the eyes, nearly one-fourth of the body distance back from the anterior tip, there is a very slight constriction, which is gradual in slope and does not appear unless the animal is quiet and nearly fully extended. Posterior to this, the body diameters are very nearly the same as far back as the last one-fourth, where there is a gradual and even narrowing toward the truncated tail. The ventral durface is somewhat flat, but the lateral surfaces very gradually round upward so that there is only a very narrow entirely bottom surface. Color seems to be lacking. The opacity apparent to the naked eye disappears under the microscope, showing only a very transparent body. Even the outline is not as definite and clear-cut as in many other white forms. The intestine shows somewhat darker than the clearest portions but the outline is almost invisible. The eggs alone are dark and thick, but show no especial color. The atrium seminalis and sexual pore show as very gray-orange with smooth walls distinguishable from the cellular parenchyma. This parenchyma gives a pale greenish tinge to the

body as a whole.

The epithelium is thin and clear, the cell outlines hardly visible and even the inner margin not distinct. It is of nearly even thickness over t he body except on the ventral surface of the t ail, where it is made heavier by cells specialized as a holdfast. There is no such highly developed point on the head, since the animal nearly always holds the anterior end a little elevated, so that it does not come in contact with the substratum. The rhabdites are very inconspicuous, being small, regular in shape, and clear. They are straight rods scattered thruout the integument, to some little extent grouped together in threes or fours but generally lying in various positions, tho almost never end to end. The cilia are fine and are about the thickness of the epithelium, in length. They are distributed evenly over the surface of the body. Their movement is regular and gentle with no heavy waves of motion. This lack of power is to be correlated with the crawling rather than the swimming habit and also with the strong muscular contraction which causes a large amount of bodily t wisting and turning. There is never the smooth gliding motion so characteristic of types propelled by ciliary motion. The tail portion alone has specialized cilia. Over the upper surface and to some extent down on the ventral side there are cilia which are about four times the size of those of the rest of the body. They are from twenty to thirty in number and rather irregularly placed, s tanding out stiff and spine-like in all direct-

ions. They do not flex and wave as do the others but are more rigid, thicker walled and conspicuous. They are sharply pointed with somewhat broad, heavy bases, and are evidently sensory in function. With this exception, the integumental details appear specialized to only a small degree.

The muscular system is important. The muscles are many cells or fibers running in a more or less longitudinal direction tho often somewhat oblique. These connect the anterior regions with the posterior end and are the principal source of locomotive power. The muscles which control the action of the head are stronger on the dorsal side and run in a number of directions, interlacing to form a network strong enough to lift the bulky head. The action of the pharynx is also heavy and forceful, in fact this is one of the most muscular species. But with all this power of contraction, the muscle strands are still so delicate as to be very nearly invisible. They are never concentrated as to be at all solid or firm, are rather single cells depending for their strength upon the sum of all their work.

The parenchyma is visible as a transparent material making nearly one-half the body mass. It is almost the whole of the large head and extends back completely surrounding the intestine and reproductive organs, even filling the broad tail region. The cellular structure is evident even tho its extreme delicacy makes it appear almost a cobweb. The cells have several long, irregular processes, running in all directions, making a network

much like that of other forms but less heavy.

The digestive system is thin-walled and in all specimens very nearly as transparent as the parenchyma. Its boundary is somewhat irregular and the elasticity or limit of extension less than in many species. The pharynx is nothing more than the narrowing of the anterior end of the intestinal cavity to the mouth region. It is not at all marked off from the rest of the digestive tract so that its limits cannot be distinguished. The mouth when closed is a thin slit just posterior to the eyes, when open it is triangular or roundish in shape, the wider part being anterior. The bounding wall around the mouth is wide, about twice the thickness of the integument. It is well-defined and shows the muscle strands which control it. The intestine itself extends far back into the tail region but not much farther forward than the mouth. The cells which make up the wall are rather large, and squamous-like, but their boundaries are not heavy enough to be distinguishable. They do not show the large oil globules found in many species and the protoplasmic content is much more fluid.

The nervous system consists of an angular brain ganglion upon whose surface the eyes are placed. This is about one-fourth the body length from the anterior end and leaves a broad undifferentiated space before it, a detail which recalls the like condition in Macrostomum sensitivum. The eyesare dark, very small crescents, placed near together. They call attention because of diminutive size together with intensity of color against a light

background. There seem to be no other especially developed sense organs, which is not surprising in an animal so sluggish in movement and so lacking in definite reactions.

The reproductive organs are conspicuous because of their opaque grayness and consequent visibility. The testes are distinctly dull colored and extend from the ventral posterior region up around and forward partially clasping the intestine. The ovaries are just back of the testes on either side. This form differs from others of the genus in that eggs develop thru the maturation stages in two diverticula of the ovarian ducts. These are simply elastic expansions of the ovarian wall and its duct and with the enlargement of several consecutive eggs it pushes forward to a point only a little posterior to the mouth. A number of eggs of various sizes will thus lie in a row on each side of the body, the largest posterior, down near the sexual pore and those farthest forward not more than one-half the size. The female genital pore is very large, about one-fifth the distance from the posterior end. It is irregular in shape, and with a thick wall. The male pore is slightly posterior and much smaller and thin-walled. The reproductive season is during January and February. Evidences of asexual budding were not present.

The general points of comparison with other species are briefly: First, differences in shape. The head is much longer than *Macrostomum sensitivum*, the tail much narrower than *Macrostomum appendiculatum*; second, the eyes are very small, much far-

ther back and closer together than in either of the other two forms; third, the male chitinous spicules are shorter, more simple and not so sharply pointed. Other details in which the members of the group show some semblance are the very light color, the large, hair-like cilia at the posterior end, the large mouth and comparatively simple intestinal cavity, the position of the ovaries, dorsal to the testes, and the generally spatulate tail.

Family PRORHYNCHIDAE

The family name Prorhynchidae was suggested in 1862 by Diesing for the one genus, Prorhynchus, at that time containing a single species, P. stagnalis, which had been described by M. Schultze in 1851 as a seemingly aberrent form. It possesses an armed proboscis-like structure so resembling the stinging apparatus of the Nemertinea that the early authors thought it must be an intermediate type. vonGraff, in 1885, pointed out that the so-called proboscis was merely the stylus of the copulatory organ situated far anterior, and that there were really no special characters to relate this species to the Nemertinea. Thus the integrity of the family was settled. Eight other species have been added to this genus but even yet the family remains the smallest of the Turbellarian group. The nine species are strikingly similar in a general way, the differentiating characters, however, being well defined. Two species, Prorhynchus stagnalis and Prorhynchus applamatus have been found in the United States, the former in New York and in brackish water at Falmouth, Massachusetts, the latter in a greenhouse in Lincoln, Nebraska.

Prorhynchus stagnalis M. Schultze 1851

Several specimens of this species have been found in ponds at Urbana, Illinois. They were taken during the latter part of April, from the protected side of a muddy bottomed little lake. They came with the mud or loose silt at a depth of three feet, where the water was fairly clear with little or no algae.

In a large aquarium of this same pond water, their actions were watched. Superficially, they resembled little white leeches, both as to general shape and the manner of retracting the whole body and then stretching it out quickly, the head free searching in all directions. This motion was c onstant for lengths of time, the animal seeming almost frantic in the quick nervous motions. It crawls over the glass wall of the cquarium, covering quite a distance as it does not hold its course much of the time. It also creeps up and down the larger stems of Chara and other water plants, but never is free-swimming. All the movements are of the muscular type and are precise and quick. There is only a weal ciliary action w hich has little to do with the locomotion, as it is as heavy when the animal is quiet as when it moves. The power of contraction is well-developed, the animal often drawing up to one-fourth the extended length. The average when at rest is however between one-half anf three-fourths the greatest extension. A noticeable fact is that when drawn up and quiet the width is not changed, the extra enlargement having its effect entirely upon the delth. When thus contracted, the head is not generally drawn nearly straight back up to the heavier part but is more or less bent to one side so that the form is not compact but irregular.

The general appearance was striking and characteristic. In size, there is little variation, the length being very nearly four millimeters and the width 0.5 mm., for any part of the body. The shape is noteworthy, being a regular oblong with only little

change at any point and as a whole it is thin and flat, the only appreciable thickness being thru the intestinal region just posterior to the middle where the dorsal surface rounds up to some extent. At both anterior and posterior ends the depth is exceedingly slight. The head is sharply truncate, square with the ciliated pits smaller than reported for other forms. The posterior half of the body is much larger and darker than the European type, showing a greater contrast with the margin and with the head which is extremely transparent. The pear-shaped cells in the integument seem to be more conspicuous than is usual, as they are clearly outlined against the rest of the epithelium. Since there are very many so that they are arranged close together. The parts of the structure appeared clearly. A large outside portion made of a single cell with thick definite wall contained an eccentrically placed smaller part round and dark in color. This evidently bears some relation to the nematocysts and rhabdites of other species. These details are of some interest in showing the amount of variation in a single form.

<u>Prorhynchus</u> <u>applanatus</u> Kennel 1888

During the month of February, in collections from under the ice, individuals of this species appeared crawling in masses of Cladophora. This is a very different habitat with different environment from that of a greenhouse where it has been found before. The animal was noticeable on account of its pure white color and quick, jerky movements as it crawled thru heavy

tangles of the algae or hurried over the side of the aquarium jar. In a few respects, it differs from the type descriptions. The body is not more than three millimeters long when fully extended and about one-fifth as broad. It is extremely flat thruout the dorsal side, the arching over the intestine being slight. The shape as a whole is not so slender as Kennel's drawings, being nearly an oblong with parallel sides and nearly parallel ends. The anterior surface is deeply notched at the point of the mouth opening, giving the two lateral corners an almost lobe-like appearance. This, with the clear transparency, makes the head-region conspicuous. The tail end is much more rounded and short than in other cases, which causes the whole body to seem broader. The color as a whole is much denser and purer white than in Prorhynchus stagnalis, showing a yellow tinge only over the intestine.

The pharynx shows clearly its division into heavy, large secondary cells which act as a support for the four pointed tooth-like cells which work in connection with each other and recall the Aristotle's Lantern arrangement in the Echinoid. They are relatively large and muscular, occupying one-fifth the body length. The method of working is striking, as the movement is entirely confined to the narrow space within the pharyngeal wall. There is little expansion and the limits of motion are narrow but this is balanced by the drawing backward and forward of the whole structure which gives a purchase on whatever material is held at the mouth opening. The intestinal diverticula are large but very

irregular and many are not straight but curved and bent. This differs from the extremely even condition in the original type.

One other detail might, perhaps, be mentioned, the small size of the eyes. They were of the same bright color but were not more than one-half the size given for the European specimens.

Family TYPHLOPLANIDAE

In 1831, Ehrenberg used the name Typhloplana for one of the twelve genera which he described at that time as making up the new class Turbellaria. Five years later he described the genus Mesostoma, which gave the family name used until 1905, when vonGraff outlined the general characters and gave the distinguishing limits to the group. He then proposed the name Typhloplanidae from the oldest genus of Ehrenberg, for this new family,which included only the old Eumesostomina and a few new genera described by Luther (1904). The other parts of the Mesostominae Duges were made separate families. The Typhloplanidae stand now as composed of three tribes, as suggested by Luther (1904); six and two genera respectively. Of all the Turbellaria, this family is the best known. As vonGraff says, the histological work of Luther and the descriptive work of several other writers have made possible a clear understanding of their morphology and biology.

Nine species belonging to this family have been reported from the United States, all from localities in New York except two, Bothromestoma perconatum and Mesostoma ehrenbergii, which have occurred in Michigan and Illinois. To this list, may be added several others.

Rhynchomesostoma rostratum Muller 1773

This is, perhaps, the most delicate of all the rhabdocoels. One of the very first to be described, it has appeared

again and again in many places. It is naturally a northern form and is found in cold water, under the ice or early in the spring. vonGraff had specimens from a peat-bog in Rochester, which measured only 2 mm. Those which I have had came from a small temporary pond with a muddy bottom covered with dead leaves and sticks and a little algal growth. The water was never clear and was in the process of drying up. The length was in every instance more than 2 mm. and a few individuals were 3 mm. long. They were all, however, very slender when extended with the anterior and posterior ends drawn out to a very long, sharply pointed tips. The whole body made a regular spindle with the pharynx protruding only slightly on the rounded ventral side. The contraction of the proboscis-like head is more conspicuous than in the European forms for it can be withdrawn into the body back to a point even with the pharynx, thus making the anterior surface the largest width. The two rings of muscle attachment were to be clearly seen. The tail was not at all retractile. The color is noteworthy. Since the integument is exceedingly transparent, the internal parts are easily distinguishable. The parenchyma is in all my specimens of a clear, pale rose, without the slightest tinge of yellow. Within this the intestine and reproductive organs showed definite outlines. The wall of the intestine is somewhat gray, with very small cells which are nearly all of the same size. Scattered among these are bright carmine-red oil globules of about double the size of the other cells and evenly distributed over the outer layer of the

digestive tract wall. These helped to add to the general reddish color. Of the reproductive organs, the ovary, testes, and atrium were grayish with clear, sharp walls, and were not conspicuous. On the other hand, the developing eggs and vitelline glands are of a deep, brilliant red. The glands are compact with irregular lobed margins about one-tenth the total length of the body and near the surface on each side of the body at about the middle. They varied in size but not in intensity of color and came down to their connection with the atrium as a very narrow thread. The eggs, either one or two were matured in the atrium which formed a sort of egg capsule. The color was lodged in the tough, thick shell which was with all sufficiency transparent to show the yolk granules within. These yolk granules when removed from the shell were white and clear, of somewhat varying size. One set of eight eggs measured showed diameters varying from 22.9 to 28.8 . They were very nearly spherical, two diameters in a single egg generally differing not more than 5 . They lay just behind the pharynx in the heaviest part of the body and were visible even to the naked eye. The specimens were taken during April and all were carrying eggs which often were extruded as the animals were isolated in watch glasses. The first developmental stages were carried thru but most of the eggs dies before the second cleavage.

This mud-loving form is, of all the Turbellaria, the most ethereal, it is daintily tinged, a mere transparent shadow against the dark background.

Typhloplana viridata Abildgaard 1790

This is another species taken frequently during April and a few times in the summer and fall. Altho very evidently to be identified with the European form, it varies somewhat from that, and also from those specimens already found in this country. The animals seem to come entirely from bottom water or from masses of algae living close to the bottom. The size variations are interesting. Three-fourths of the individuals were very nearly 0.5 mm. in length tho they were quite often different in plumpness. The others seemed quite long and slender in comparison, tho they measured only about 0.75 mm., but the relative width was less. The shape was quite different from other forms. The slope toward the tail is much more gradual altho the point itself is not sharp, that is, the posterior region is not blunt and stubby, but more slender. The middle part of the body is round and not so cylindrical; then, too, it slopes into a slightly narrower neck-like portion which again rounds out into the head. This head, except for shape, can hardly be differentiated from the tail end, as it does not possess eyes or specialized sense organs of any sort. It is quite round and nearly as broad as the widest part, tapering not at all. On the whole, the shape is more like some of the related genera than of this species. The anterior end is much more contractile than the rest of the body and there is almost no contraction possible back ofthe middle line. The amount of contraction, however, is very much less than most nearly related species, and neither is

there the twisting and turning which is characteristic of other types. That is, the body seems stiff and solid. The c olor varies even to the naked eye. It depends upon the amount of green present. It is sometimes quite deep and brilliant, at other t imes pale and often almost a gray. This gray is the real color of the parenchyma and is due to absence of the pure green coloring matter. When there are a number of winter eggs, large and nearly mature, they alter the general appearance, giving a dull brown tinge which sometimes may be quite dark.

The integument is very clear, showing not at a ll the cellular divisions so plainly to be seen in some forms and thus seeming almost homogeneous. The c ilia are not at all clearly noticeable, as they are very fine and not differentiated. The rhabdites are v ery small and lie in the parenchyma just beneath t he epithelium. They are not arranged in definite tracts but are scattered all thru. The thickness of the integument is somewhat surprising, as for such a small form it would hardly seem proportimate for the one layer of outside covering to reach a thickness equal to one-tenth the body diameter. The parenchyma is unique in every respect. The only cells which are conspicuous are those which contain the bright green color bodies. Those bodies a re spherical and all of about the same size and arranged in a nearly solid mass within the cell wall, which is in every instance so filled that the surface shows the outpushings of the solid bodies within. This makes the surface slightly rough. The wall, however, is fine and

delicate, partially elastic so that the boundaries of the green bodies are visible. Most of the cells contain from six to ten bodies but an especially large one might have as many as eighteen or twenty-five. These zoochlorellae are not at all regular in their placing, being scattered a few here, a few there, thruout the whole body. There were never, however, very many in the part anterior to the pharynx, a fact which makes the head much lighter in color. Other parenchyme cells are of thecommon transparent color and are hardly visible unless the zoochlorellae are so nearly absent that the- remaining cells are not obscured. The thinner material which makes up a part of the colored mass is more sharply differentiated than in other types. Its very homogeneous fluid nature is evident. It is a very smooth light green, but whether the color is merely a reflection from the zoochlorellae or is an intrinsic quality developed as a result of their action is hard to ascertain.

In most of the specimens taken during the spring, a number of eggs were present. These varied in number from one to ten, and it is probable since it was near the last of the winter season that in those individuals carrying one egg, that was the last, the others having been laid, rather than that it was the first with others to develop later on. The one or two eggs always lay in about the middle of the body, and where there were more, they crowded forward toward the head, sometimes almost completely filling the whole anterior half of even two-thirds. They were in two rows

except in a few instances where one, the oldest, occupied a position ventral to the others and nearer the sexual pore. Since these were winter eggs, it was not surprising to find them with very thick shells. These shells were dark brown and about one-ninth the diameter of the egg in thickness. For the size of the animal, these were very large, measuring 8 to 12 across. The yolk cells showed thru very distinctly and were all of the same size. They were large and few in number, giving a very different appearance than in the case of those where the yolk mass is finely granular. With a strong light, the nucleus was visible as a large clear spot. Of the other reproductive organs, the cirrus could be made out large and almost transparent in the parenchyma. It was nearly as large as the pharynx and clearly showed the concentric layers of cells in the wall. The sexual pore was guarded by a broad band of circular muscles. The testes appeared quite large and solid.

From the several descriptions given by different authors and in the above details, it would appear that this species undergoes a greater amount of variation than is possible in many forms.

<u>Mesostoma ehrenbergii</u> Focke 1836

A form which I have called <u>Mesostoma ehrenbergii</u> has been taken from a little pond near Urbana. It is a common European species which has been identified from a number of places in this country and much variation very probably exists. In several respects, these specimens differ from others but they seem likely to be the result of environmental conditions rather than of specific

importance. They are essentially bottom lovers tho they very quickly creep into and thru any heavy mass of filamentous algae. The length was always between three and five millimeters, which is a reasonable average but the width and depth were entirely out of proportion. Instead of a flat, leaf-like structure, the width was mot more than one-fifth the length while the average depth was something a little less than the width. Both these measurements, however, differed greatly in the different specimens and in the same specimen at different times. The whole shape was slender, cylindrical in a general way. The head end showed the characteristic conical, bluntly pointed portion with the rhabdite tracts very conspicuous. It was flat and being constantly moved in all directions. The tail was not pointed sharply but tapered to a short, blunt tip. Some ofthe specimens were much inflated with young worms but this inflation was almost entirely effected on the upper surface alone. At a point just posterior to the eyes, the body wall very sharply rounded upward, making the head only a flat projection of the whole mass. The posterior end more gradually narrowed but the whole animal was exceedingly inflated. In the collection, a good many young individuals appeared. These were always more regular in outline, the head and tail ends tapering not at all and the width being nearly the same thruout the body. Another rather distinctive detail was conspicuous in specimens not swollen with young. This was a definite fold or angle about midway between dorsal and ventral surfaces and running from near the an-

terior end far back, almost to the tail. This fold was marked by thickness of the epithelial cells and by a lighter strip and then a darker strip. Such a fold has been described for very flat worms but not for such a round, compact type. The line of demarkation between the dorsal and ventral surfaces was also definitely developed as a lighter, heavier streak. Since the ventral surface was flat, this line was never to be seen unless the animal was partially turned on a side. This ventral line and the lateral fold were very much alike in appearance and structure. The color varies from a delicate to a dark brown and is lodged in the parenchyma. For this reason, the anterior head region in which there is little room for middle cells is entirely clear. The color is not the same over all parts of the body but is concentrated in a wide dark strip down the middle of the dorsal surface. Then, also, the folds and angles along the edge are banked by a heavier band. Young individuals showed very pale yellow and those just born were entirely without color. The rhabdites occur in the parenchyma in close relationship with the color cells and are sharply defined and clear. They lie in groups of six or ten or are promiscuously scattered and the head also shows heavy tracts. In shape, they are straight rods with rounded ends and without any variation in diameter. Under a lens, the rhabdites give the parenchyma a checkered, rough appearance. The intestine is much narrower than in most species of this size and is consequently more compact and also of greater depth. The pharynx rosette is a flattened sphere, that is, the upper margin is

somewhat drawn in and the whole structure is more or less round, as differing from the flat, open funnel in other genera. The mouth is very small. The intestine seems not to extend farther forward than the eyes, a possible reason being the lack of space in the head. So much for the more or less general characteristics.

The most striking detail of the whole body structure is, perhaps, the complex reproductive system and the viviparous habit. The yolk glands lie next to the intestine and are opaque to such an extent as to be easily distinguishable from the other organs. The ovaries and testes are inconspicuous except during a short period of especial activity. Among the number of specimens bearing several developing worms, two or three were especially prominent. In one of these, twelve embryos could be seen, seven in the right and five in the left uterus. They were closely packed and most were somewhat curled up, the anterior end sharply bent on the other end. The movement was mainly a constant stirring the several worms gliding over each other more or less and to some extent changing their position in the body. The mother was finally killed, cocaine being used to produce anesthesia. By this method, the regions of greatest contraction were made out. The head and the region posterior to the pharynx are drawn toward the anterior middle part which very greatly increases in diameter, making a heavy knob-like portion. These contractions drove all the embryos to this region where they were tightly massed. Another specimen showed seventeen embryos on the right side and twelve on the left. These were large, one-fifth the total length of the

body of the parent, but were not so confined as the younger specimens. The wall of the uterus is heavy and not elastic, but so enlarged as to give ample space within. All the young worms were active and were incessantly hurrying from one end to the other, crawling over each other in the most promiscuous way. This enlargement of the uterus pushed toward the center the intestine and what little r emained of t he yolk glands. The t estes had almost completely disappeared so that the main portion of the body on each side was occupied by the large transparent uteri. These, however, were extended only as far forward as the head region. The extra space needed wasgained by a dorsal swelling, the central upper surface being extraordinarily extended, making the shape of the animal most grotesque. The two uteri connected with each other across the middle line by uterine ducts but there never seemed to be any intermingling of the individuals from the t wo sides. This was evidently because the duct was too small to admit of the passage of so large a worm. By the time the embryos were ready for birth, the duct would be stretched but the tendency would be to pass to the exterior rather than across the body, since in that direction the resistance would be less. The young worms in this specimen and in the one mentioned above showed clearly two of the later stages of growth. In the first, the embryos were not long in proportion to width, the head was not at all marked off from the body regions, and the intestine was nearly clear. In t he second example, the embryos were much more elongate, the head tapered off slightly and

the intestinal wall was visible as a light gray wall with many very regular globular cells. The eyes in both were prominent. In the older worms, the pharynx was also fully developed and in fact more conspicuous than in the adult because of the transparency of the parenchyma and intestine and also because it was relatively very much larger. The tracts of rhabdites had also become heavy enough to be visible and most of the body structure was perfect. When, by accident, the body wall of the parent was broken, all the embryos pushed out and swam away, seemingly perfectly at home. In the collections together with the adults a larger number of small individuals appeared. In size, these outreached all the unborn embryos only a very little. Thus it seems that the young are retained in the body of the mother until a very late stage in their development.

Mesostomum simplex nov. spec.

A number of specimens of this form appeared in a pond together with Mesostomum ehrenbergii and others of the same family. In many respects they closely resemble the more common species. That is, the general shape, the pharynx rosette, the slender body, the black eyes, anterior tracts of rhabdites, all very closely resemble those of other genera. In certain details they vary to a durprising degree, being decidedly different from their contemporaries.

Several points of general appearance are notable. The size, altho not at all constant, is not over 1.5 mm. long by 0.45

mm. broad and 0.3 in depth. This is much below the average for Mstostomum ehrenbergii. In shape, the difference is more pronounced. The head end is rounded, tapering only a very little, and not at all constricted or differentiated from the body region. The diameter is about the same at all points except, of course, there is some little narrowing toward the tail. The head end is contractile and as the animal moves, it is turned from side to side and stretched in various directions. This causes more or less change in general shape, the tendency toward a pointing of the anterior tip showing most readily. The ridge dividing dorsal from ventral surface is well-developed around the head and this often comes into view as the animal reaches up and out. The color is a light yellowish-brown and is as usual lodged in the parenchyma. It is very even all over the body, which is quite the opposite from the condition in Mesostomum ehrenbergii. The anterior end, even, is not the least different in tinge from the rest. The integument is thick and clearly defined. It is transparent and of nearly equal thickness all over except at the angle and in some special anterior portion which seems to be more sensitive. The cilia are not heavy and are evenly distributed over the whole surface. The rhabdites arescattered in a layer thruout the body just beneath the epithelium. Then, also, there are several prominent tracts arranged in a narrow fan in the middle part of the head. These lie dorsal to the brain, running back between the eyes, but they are heavy enough to be noticeable only far forward. They are not so con-

spicuous as those of *Mesostomum ehrenbergii*, where they are sharp against the clear background. The parenchyma of this new *M. simplex* is especially well-developed, taking up most of the space in the body. The cells are close together and there appears to be less fluid than in some forms, being almost undefined. The contained matter makes only the central portion darker, and does not particularly intensify the wall cells. This conditions does not at all obscure the pharyns which stands out dark and heavy. Its size is large comparatively and the rosette cellsa re rather long. This specieshas not been taken when in the reproductive stage. The above outline summarizes the notable characters.

Family DALYELLIIDAE

The Dalyelliidae have had an irregular history. Starting in 1843 with the descriptions of Oersted and continuing to the present time, this family has been the subject of descriptive and systematic studies. Oersted named several species belonging to the genus Derostoma and then proposed the family name Derostomeae. Schmidt (1848), Ulianin (1870), and Jensen (1871) worked over this family adding species and defining the genus characters as well as describing several genera belonging to other nearly related families. In 1882, vonGraff reclassified the whole group, incorporating with Derostoma the old genus Vortex Ehrenberg (1831) and naming the family from the latter genus. He created two sub-families to contain the eight genera. Then, later, in 1903, he again renamed the Vorticiidae, making a family, Dalyelliidae, with two sub-families, the Graffillineae and the Dalyellinae named after the two oldest genera, respectively, and at this time also because Vortex had been used in 1797 for another form he suggested the name Dalyellina first used by Fleming in 1822 for that genus. Again in 1908 on the basis of a paired ovary he made two failies the Graffillidae with two ovaries and the Dalyelliidae with only one. The latter family was made to contain six genera and sixty-one species, all European forms. Before 1911 three or four species had been identified for this country, all new. In his paper of that year, vonGraff described eleven others, most of them taken from the locality around Rochester, N.Y.. Thus the present con-

ception of the family is quite different from the early original description.

The more general distinguishing details are the presence of a single ovary and two yolk glands, a simple genital pore, and the anterior barrel-shaped pharynx without a sheath.

The pharynx is the most clear and easily seen of any character. It is often slender and long, often short and nearly spherical, but generally the checkered appearance of the wall is well-developed. It is always of relatively large size and holds its shape constantly, not being at all collapsible. It is thus very sharply marked off from the intėstine which is very different in structure. During the reproductive season the vitelline glands running forward on each side of the intestine are very prominent. The ovary, testes, and other accessory parts are often so embedded as to be difficult to make out, but always the yolk glands can be seen nearly as large as the intestine itself, extending up around it toward the dorsal side. In many instances also the rather large opaque egg is evident more or less completely filling the posterior region of the body. The anterior end is commonly truncate with the mouth a conspicuous whole just ventral to the very front margin. The development of a tail-like portion is somewhat variable but all the forms show at least a tendency in that direction. The shape as a whole is much more slender in many families. The color ranges from almost black to clear transparency. The above summary mentions points in the general make-up which causes this

group to be one of the most easily recognized of all the families.

Dalyellia dodgei vonGraff 1911

This species was taken together with half a dozen other rhabdocoels from a small temporary pond which during April was up to four feet deep but which later would dry up completely unless the rains were especially heavy. It drained down into a little river so was not entirely cut off from outside species. There was a muddy bottom with some algae and many leaves from nearby oak trees. The site was protected from wind by little hills so that the warmth of the sun was felt early. The special locality was the surface of bottom mud or a small mass of algae. Either was a good hiding place as the animal was nearly black. The motions were sluggish and not constant. When at rest, the body was drawn up to one-half its extended length and seemed almost round. It was not as easily frightened as most of the other s pecies and when aroused more quickly became quiet. One little habit was quite noticeable. Very often when the rather small mouth was opened, the front end of the head was slightly elevated to give the ventrally placed opening a more advantageous position. The two corners of the head were very contractile and were used almost like lips to guide particles of food into the opening between them. When the animal was moving along, the mouth was closed and the ventral surface held down. The head was never turned from side to side, and the whole body was straight, keeping to a rather definite course for the most part.

This form agrees closely with that described by von Graff from Rochester. He speaks of it there occurring more frequently than almost any of the others. The conspicuous characters are double arrangement of the pharynx with its especially developed papillae, the mottling due to scattered pigment cells and the complexity of the reproductive organs. This western type is noteworthy as showing the distribution of a species found commonly in a certain restricted locality and seems to be indicative of its probable wide-spread occurrence. A resume of its variations may be of interest.

In size and shape, my specimens are very nearly those of the eastern form but the color is strikingly different. Altho showing a sepia-brown when the animal is compressed to such an extent that the parenchyma is in a thin layer, yet under ordinary conditions it is very dark. It appears evident that the pigment cells when fully developed lie so close together as to aggregate in a color nearly black. It is really a dull brownish-black, so opaque as to entirely obscure the internal organs. On account of this color in the parenchyma, the integument by contrast is exceedingly prominent. It is especially thick and possesses an almost irridiscent transparency. It so reflects the light as to show the convexity of the body surface. This gives an appearance of solidity not present in most specimens. The cilia are fine, clear, and very swift and heavy in their motion, as a result of the lack of a strongly functional muscular system. The parenchyma is com-

posed almost entirely of pigment-bearing cells. That is, there is no layer of colored cells on the outside just beneath the integument as is commonly the case but most of the parenchyme cells contain more or less pigment substance so that the color is scattered. The fluid material is present but it is not conspicuous. In shape, the cells are irregular and in most respects they resemble the parenchyma of other forms. The digestive tract is different from the type only in minor details. So covered by the pigment that it is not apparent when crushed out from the surrounding tissues, it shows the characteristic green of the wall cells. The pharynx apparatus is especially long, extending back thru more than one-third the body length. The anterior vestibular portion is shorter than the pharynx proper, but is of about the same diameter. The papilla are very slender and lie far apart.

The only point of note in regard to the reproductive organs is the duct leading from the uterus to the genital pore. This is extremely slender and long, a mere thread reaching up into the body mass for a distance almost equalling the main diameter. In specimens where the egg is large and ready for laying, the duct appears incapable of such extension as is necessary for the passage. The yolk glands, testes, and ovary lie embedded in the parenchyma.

It seems probable that tims species feeds upon the minute algal growths in the masses of filament where it habitually lives or upon plant debris just below on the surface of the mud.

It presents a type of structural detail very different from most other species.

Dalyellia fusiforma nov. spec.

Specimens of this species were found in abundant numbers in a sand-bottom pond together with a half-dozen other rhabdocoels. The habitat conditions were somewhat extraordinary, a fact which will account for the specialized structure of all the species. It was taken always from masses of Nitella and never from the bottom or from any other plant tangles. In the aquaria, it very freely swam out into the open places and was not one ofthe lurking type but in the pond was never taken from open water. Possibly the reason for this was the presence of food in the algal masses of the pond which would constantly attract.

Even to the naked eye, these specimens were surprisingly different from the general type, and the distinguishing details are all of a conspicuous nature. Never more than one millimeter in length, the average was much less. The greatest width and depth are at the middle and are both a little less than one-third the length. The shape is a rather uneven spindle. The anterior end is very bluntly pointed, the two lateral margins making an angle of 35°. The tail end, however, tapers out to a slender rounded tip which is almost always held slightly curved or bent to one side, so that altho the animal when moving follows its course constantly, the body is never quite straight. This habit was much more pronounced in some specimens than in others. The portion between the

head and tail is quite thick and solid in contrast to the attenuated extremities. It is cylindrical for only a short distance as the sloping begins very gradually. The contraction is not as conspicuous as in many forms but is better developed in the tail region than is common. The lack of a neck constriction and the shape of the whole anterior tip precludes much movement from side to side and the body as a whole is fairly rigid and stiff. The color is nearly white, opaque to the naked eye and not very transparent under a lens. The only direct color, however, consists of a lattice work of heavy pigmented cells in the extreme anterior tip. These color cells are arranged in long, angular criss-crossed rods which are quite irregular. They make a maze of dark brown sticks surrounding and obscuring the eyes.

The integument is thin and transparent with well-developed cilia used to a great extent in locomotion. The rhabdites are small rods so clear that their concentration in parenchyma tracts is hardly distinguishable. The thickness is nearly uniform over the body except some little differentiation in the tail region which is used as a means of attachment.

The parenchyma is not heavy or closelt meshed but is more opaque. It forms the supporting cushion layer for the pigment mass in the head, keeping the cells within their relative portions.

Dalyellia alba nov. spec.

The habitat of this species presents conditions very nearly like those of most ponds. A muddy bottom, with roily dark water, some amount of leaves and other organic debris, much floating Cladophora make a surrounding environment suitable for such rhabdocoel types. Chief among these is Stenostomum leucops. The Dalyellias are always taken from masses of algae. They appear to find in such a situation both a good feeding ground and a safe lurking place. In very many hauls a few specimens appeared but they were never in such numbers as Stenostomum and were never so boldly free-swimming. They were often seen, however, gliding out from mazes of filament and seemed to swim partly by ciliar action and partly by muscular contraction. They spend most of the time clinging or crawling among the algae but when removed to a watch glass or aquarium never seemed to creep over the surface as do other species. That is, their methods of attachment were not developed and the locomotion was entirely free.

The general appearance much resembles a short, heavy Stenostomum. The length varies from 0.75 mm. to 1.0 mm. but seems much less owing to the relative great width. The width is about one-fourth the total length except thruout the posterior third, which is narrowed as a tail portion. The depth varies at about the same rate as the width and is always very nearly the same for any given part. That is, the ventral surface is convex with no flattening. The twisting and contraction are only slightly developed,

tho the body is not as rigid as many forms and the head is often drawn in, the back humped up and the whole made into a nearly perfect sphere. Superficially, the color is an opaque-white, with a slight greenish tinge and is heavy enough to make the animals stand out prominently. There seems to be no pigment whatever, even the eyes are not brilliant or dark as in most of the genus.

Both integument and parenchyma are somewhat clear. The former is thin and regular in outline, allowing the scattered rhabdites of the internal layer to show thru. The cilia are quite definitely heavy and regular all over the surface except on the tail, where they are about five times as large. The whole end-portion of the tail region is evenly clothed with these larger cilia, making a specialized organ of locomotion. The layers of tissue beneath the skin are masses at either end of the body, and also form a thin envelope over the central body organs. This parenchyma is very closely meshed with space for a very small amount of fluid material, so that the appearance of both the head and tail is as thick and dark as the middle part. This is somewhat unusual, as the extremities are almost always nearly transparent. Another point to be considered is the fact that these two ends are of much greater relative size than is ordinarily the case. This seems the result of the storage or concentration there of so much differentiated tissue.

The central body mass is almost entirely composed of the digestive and reproductive organs, the latter during the re-

productive season occupying most of the space. The pharynx and intestine are typically simple. The mouth is ventral, lying just posterior to the eyes and opening into the heavily-walled pharynx which is cask-shaped but very narrow in front. The boundary of this rather muscular structure is sharply defined and reflects the light to such an extent as to appear shiny. It is comparatively small and not more than one-sixth the body diameter. It opens directly into the intestine proper, which is thin-walled and dark. This extends back to the genital pore. During March and April, the intestine is more or less obscured by the large yolk glands which extend forward to the eyes. These are heavily lobed but when fully developed become compact with a very thin dividing wall. Overlapping the posterior third on each side, is the testis very finely granular but much lighter in color. The ovary is small, posterior in position and lies embedded in the parenchyma. The eggs are about one-fourth the body diameter in size, are thin-shelled and gray incolor. They pass the embryological stages in the uterus near the middle or a little to one side in close proximity to the genital pore which is very large. As a whole, the reproductive system is conspicuous.

The most noteworthy details of structure may be summarized as; first, a broad head and tail region with a large amount of parenchyma tissue; and second, a small pharynx; third, large yolk-glands.

Dalyellia megacephala nov. spec.

The situation in which this species is found is of typical formation, the important details being a muddy bottom, small amount of algae and a large animal community. The general appearance is striking, due especially to the relatively large eyes and pointed head. The length is about 0.75 mm., the width 0.20 to 0.25 mm. and the depth somewhat varying but never more than the width. In shape, the animal very closely resembles many others of the same general type. The anterior end is bluntly pointed and quite flat. The middle region of the body is rounded out, is plump and much thicker than the rest. Then, the posterior end is slightly attenuated and more pointed than the head but cylindrical instead of flat. There is really no color but to the naked eye the whiteness is opaque flecked with the black spots of eyes which are large enough to be seen.

The integument is conspicuous, since its boundaries are definite and clear cut. Here again the inner wall is heavy. The cilia are very short and fine,all of about the same size and evenly distributed over the body. The rhabdites are not gathered in special tracts but are scattered thruout the inner portions of the epithelial cells. The arrangement is quite lattice-like in its irregularity, the small groups of straight rods lying at right angles to each other.

The muscular system is heavier than in many forms,as much of the locomotion is effected by means of body contraction.

It lies, however, very near the integument, due partly to the fact that the parenchyma is not abundantly developed. The lack of parenchyma seems to be correlated with relatively large digestive system, which nearly fills the body mass. The pharynx is very large and extends far forward leaving anterior to it only a small triangular area. The wall of t he pharynx is made up of two kinds of c ells, regularly placed. Those lying longitudinally are very slender and reach the whole length of the organ. Those extending around are also narrow and thread-like, and together with the longitudinal cells make a cross-hatching in the interstices of which are large, broad cells acting as a framework. The whole is very muscular and is turned and moved constantly. The position of the mouth is noticeable. When closed, it is a very short slit at the anterior ventral edge of the pharynx. When fully open, however, the posterior corner is drawn back ventrally as far as the connection with the intestine making the whole pharynx bend downward. The opening itself is very large and conspicuous. The intestinal wall is rather heavy but otherwise the details of s tructure are not strikingly different from other species of the family. The food is to some extent at least composed of the eggs of other forms. In one specimen, eleven eggs of Typhloplana viridatum were founr. It was possibly true that these all came from a single individual which had been bodily swallowed and the soft parts quickly digested. The heavy muscularity and such food masses seem to indicate a habit of voracious feeding.

The reproductive system is extraordinarily far forward with the single genital pore nearly at the middle of the body. The two testes are long, slender organs opening by a complicated sac-like apparatus into the receptaculum. The head portion of the spermatozoa is very large and is easily distinguished thru the wall of the vesicle. The ovary lies a little to one side of the middle and carries about ten eggs which in the younger stages showed very many small irridiscent globules arranged in rows along the edges where the eggs touched each other. When the eggs leave the ovary, they pass down the short oviduct to the uterus where, one at a time, they develop until they have a diameter one-fourth that of the body. At maturity, the egg is very conspicuous because of its heavy wall and solid yolk mass, showing thru even the thickest portion of the body mass.

Altogether this species possesses rather notable individual characters.

CONCLUSION

Of the sixteen families which make up the Rhabdocoela, representatives of five have been found in the United States. Up to the present time, about eighty species have been identified from the eastern states but only sixteen from the c entral region. To this list of sixteen, can be added eight new species and different localities for twelve others. From the collections just made, it appears that a great many forms found along the seacoast and in the border regions are also present far inland. The biologic conditions in the lakes and streams of the Mississippi Valley are not vastly different from those of the ponds and rivers of the eastern slope and very evidently the same species are to be looked for in both regions. When, however, such a form as Microstomum sensitivum, which is present in the brackish water of the open shore in Massachusetts appears again in the small ponds of New York and then is found in isolated puddles in Illinois, some note must be taken of its power of adaptability and some consideration must be given to the fact that a species so fragile and delicate may flourish in situations far removed from each other and of v ery different condition. Other examples of a like nature are many, and it seems not too presumptuous to conslude that while few North American species will be the same as those of Europe, the forms in the United States not separated by more than a few thousand miles will be the identical.

Another point of importance in connection with the dis-

tribution is the amount of variation found in individuals of the same species but living under different habitat conditions. This was noted long ago, in the difference in average size among specimens of Mesostoma ehrenbergii from Europe and from the United States and in the differences in both size and shape of Rhynchomesostoma rostratum from the two countries. There are, too, many minor variations among individuals evidently of the same species. This possibility of change is apparent in nearly every one of the old species found for the first time in the central localities. These variations are not of either histological or of gross anatomical structure but are rather in the relative and comparative development of the several body organs. For example, the eyes may be larger or smaller or different in position in specimens from one pond than in those from another. Prorhynchus applanatus and Typhloplana viridatum are other striking instances of minor changes. The specimens of the former from Urbana show a very much shorter posterior portion with a more rounded tail than is given in the original description; also the intestinal diverticula are not regular and straight but pointed and curved. In T. viridatum, the differences are very marked. The shape of the head region instead of being pointed is nearly as broad as any part of the body. Then, the green color is diffused thruout the parenchyma fluid and not held in the color bodies alone. These examples are sufficient to show the kind of variations common among the forms of the inland ponds.

Of the species present in different localities, some are much more widely occurring than others. Stenostomum leucops seems to be almost cosmopolitan and more than any other is found in small ponds. Others, such as the genera of the Microstomidae possessing a simple anatomy are also common. It seems evident that the more primitive types easily adapt themselves to unlike surroundings and also that they are not so responsive to environment in the way of variation. On the other hand, several members of the Typhloplanidae occur in many places. They show a greater degree of anatomical change and are thus able to exist under diverse conditions. The two genera of the Prorhynchidae which have appeared here were found only at one place and then only as a few specimens. The Dalyells are another family not so widely scattered. So far, they have appeared in only two or three places. The question of distribution is partially one of chance and partially one of adaptability. The above mentions only the general localities where the several families are found and the most prominent reason for this occurrence.

Any study of a number of families will reveal certain characters of comparative interest. Perhaps the most conspicuous detail of structure in such a study of the Rhabdocoela is the shape which is at once significant and important. Within the group there is a striking similarity of form even among types differing essentially in anatomical particulars. Never long and cylindrical like the annelid worms, never very flat like the nearly

related Polyclads, these worms are intermediate between the two. Some species are almost perfect spindle shape, large in the middle and tapering evenly toward either end, others are very nearly cigar-shaped, the head being broadened and slightly truncate. The most common variations are in the two extremities. The head may be broad or pointed, rounded or sharply angled. The posterior end often tapers very gradually making a long slender tail and often is broadened to form a heavy square spatula. Generally the anterior end is somewhat flat and the tail more or less cylindrical. Almost always the dorsal surface thru the center is elevated, altho the shape is easily explained. Most of the group swim out free thru the water or wriggle their way thru dense masses of filamentous algae and a spindle-shaped body is most easily propelled under such condition. The flatness of some species such as the Prorhynchidae is clearly the best shape for those types which habitually creep over smooth surfaces, as for instance the stems and leaves of aquatic plants. Here they can cling closely without presenting a projecting mass by which they might be easily dislodged. Then, too, the squarely truncated head will not cause any special inconvenience, as it might in free-swimming forms. Another point which may have to do with the shape is the entire lack of locomotor organs or projecting parts of any sort, and since the body is moved partly by muscular contraction and partly by the action of the cilia, extreme smoothness is a great advantage. As a whole, the shape is characteristic of the group and is closely

related to the mode of life.

The method of locomotion has been mentioned as being by means of cilia and by muscular action and the relative amount of development of either depends upon the functioning of the other. There are four types of locomotion; first, free swimming movement where there is no twisting or turning of the body; second, free swimming where the whole body rolls spirally; third, a creeping or crawling over surfaces in which instances the movement may be entirely a gliding or slipping, or may be by muscular contraction; fourth, a scrambling or wriggling thru masses of silt or debris. In the first type of movement, the cilia are large and evenly distributed over the whole body and the muscular system is used only for special contraction. Strongylostoma rosaceum is an example of this sort. The second method, of rolling over and over, is illustrated by the habit of the Stenostomum, where the spiral twisting is very marked. Again in such forms as habitually creep or crawl, the cilia are generally extremely fine while the muscular contraction of the body as a whole is well developed and is constantly used. Examples of this sort are Macrostomum album and the several genera of the Prorhynchidae which always cling to some surface and do not let go, so that they never swim out unprotected into the water. The different species of Mesostoma also have this same habit. These forms may be said to be lurking animals or bottom inhabitants, never found in open water. Upon occasion, when hunting in a mass of algae, any form will make use of both muscular system and

surface cilia in climbing around and thru tangles of filament, but generally where the activity is muscular the cilia are very small. This correlation of cilia size with muscular development is a notable one in all the rhabdocoel families.

Other characters of comparative importance are the relative thickness of integument, heavy eye pigment and extremely specialized pharyngeal apparatus. It is perhaps sufficient to mention these details, since, as a whole, the members of this group are of especial importance in elucidating many problems of general biologic and phylogenetic significance. The following outline summarizes the most conspicuous points in this study.

SUMMARY

1. In swiftly flowing streams where there is a rocky bed to furnish a sheltered place of attachment, planarians and a few creeping rhabdocoels find a suitable location.
2. For most of the free-swimming species, ponds and temporary puddles supply the best conditions. Such a situation comprises; first, a protected retreat and also a feeding ground which may be found in a mass of filamentous algae; second, a source of food which may be found among the animal communities.
3. The response to the presence or absence of oxygen and carbon dioxide is more precise than that caused by any other stimulus.
4. The reaction to light varies in different species but in most instances is negative tho not definitely so.

5. Response to temperature is to a general or diffuse rather than a localized stimulus, as for example in the seasonal change in the condition of water.

6. Since nourishment is gained mostly from disintegrating protoplasm the food relationships are very simple and altho nearly defenseless, there seem to be few enemies.

7. Strongylostoma rosaceum differs from other members of the genus in possessing large testes. The embryological stages cover a period of nine days.

8. Planaria maculata minor is a form in many respects resembling P. maculata but differing in development of eyes. It is a type found only in the Mississippi river or very near it.

9. Stenostomum giganteum, a large species with a blunt anterior end, is found in a single pond. The mouth is not as far anterior as in most forms.

10. Stenostomum glandifera is slender and possesses many small glands in the wall of the intestine.

11. Macrostomum album, a very transparent form, is found creeping over bottom surfaces.

12. Mesostoma simplex has a very transparent parenchyma and simple reproductive apparatus.

13. Dalyellia alba is a form small and light in color.

14. Dalyellia fusiforma possesses a conspicuous mass of pigmented cells in the anterior tip of the head.

15. Dalyellia megacephala has a large muscular pharynx and eyes placed far apart.

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List of Abbreviations

) = brain

of = body fold

; = cilia

com = commissure

cp = ciliated pit

cs = cirrus sac

cyt = cytoplasm

e = eye

ep = epithelium

fl = flame cell

gp = genital pore

int = intestine

int con = intestinal constriction

int gl = intestinal glands

int pr = intestinal prolongation

lrf = light refracting organ

m = mouth

n = nucleus

o = ovary

p = pigment

par = parenchyma

ph = pharynx

pi = zoochlorellae

rh = rhabdites

r sem = receptaculum seminalis

s cell = sensory cell

sp = eperm cell

t = testis

u = uterus

vit = yolk glands

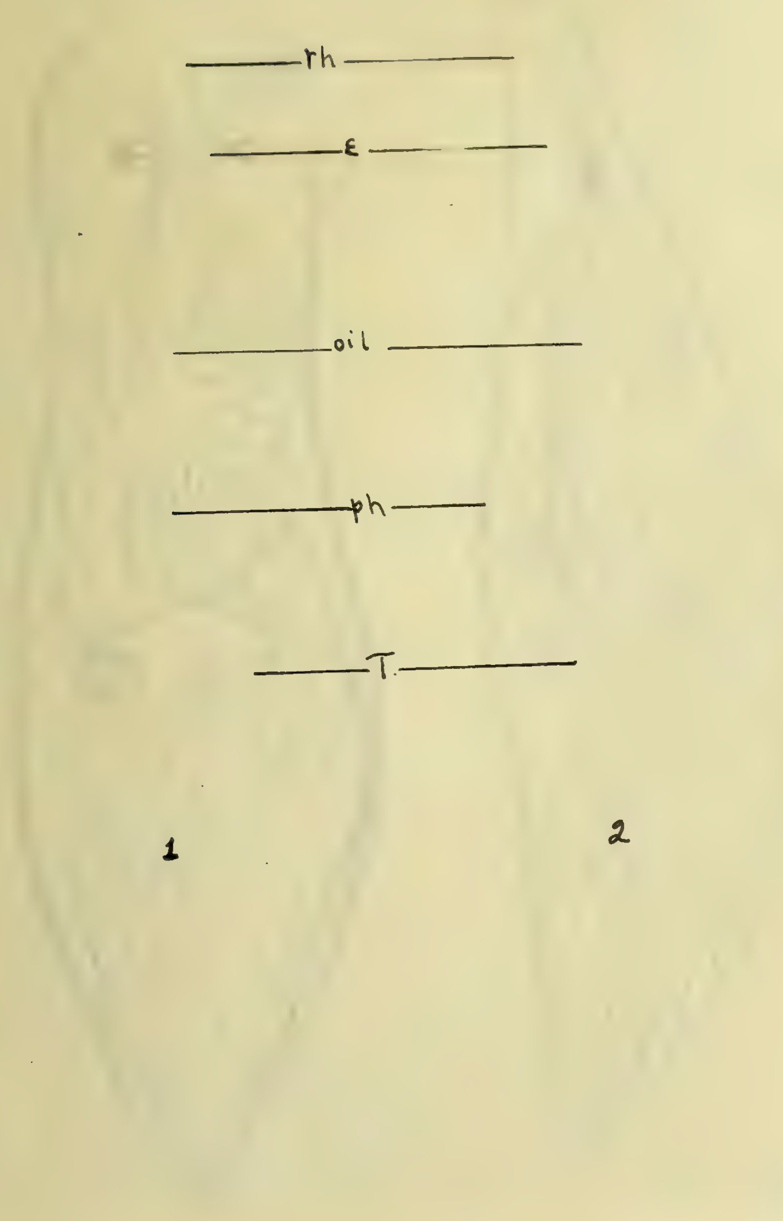
vs = ventral durface

wv = protonephridium

Explanation of Plate I

Fig. 1. Strongylostoma rosaceum nov. spec. Dorsal view, x about 150.

Fig. 2. Strongylostoma rosaceum nov. spec. Lateral view, x about 150.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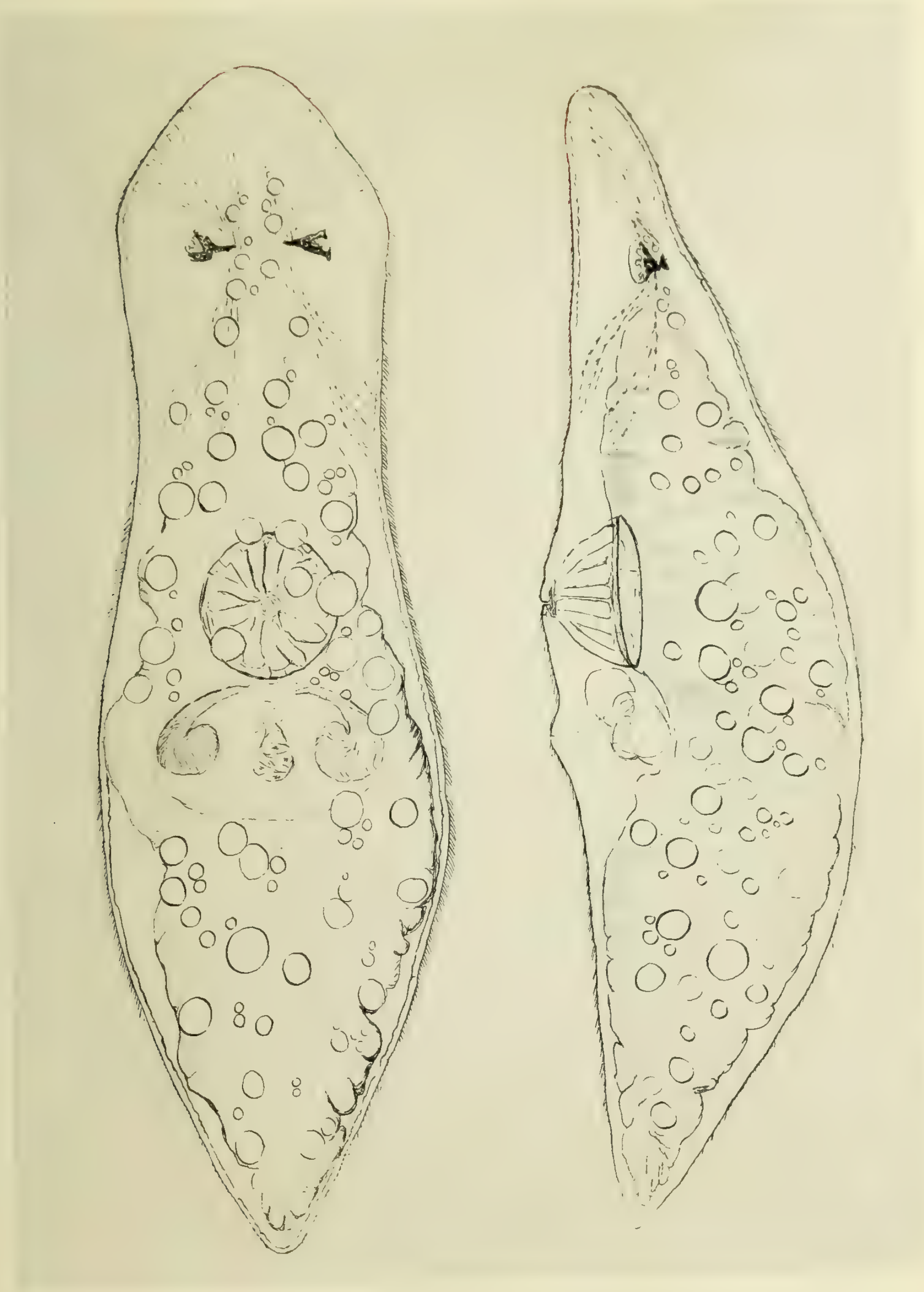


Explanation of Plate II

Fig. 3. Cyclops shell with <u>Strongylostoma</u> <u>rosaceum</u> feeding within, x about 15.

Fig. 4. Ovary of <u>S.</u> <u>rosaceum</u>, camera lucida, X 100.

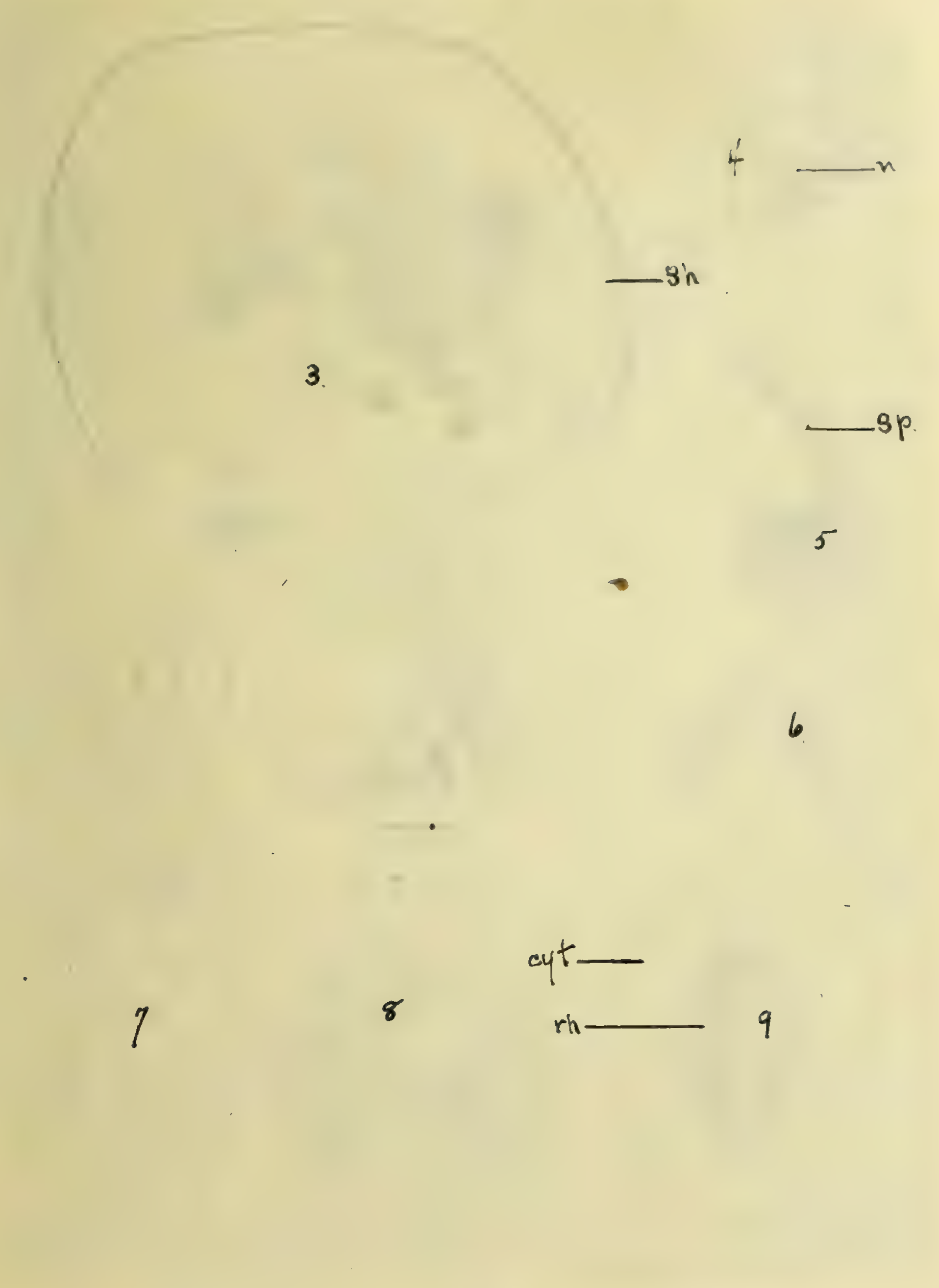
Fig. 5. Testes of <u>S.</u> <u>rosaceum</u>, X about 100.

Fig. 6. Rhabdites lying free, camera lucida, X 100.

Fig. 7. Diagram of <u>S.</u> <u>rosaceum</u> extended, X about 90.

Fig. 8. Diagram of <u>S.</u> <u>rosaceum</u> contracted, X about 90.

Fig. 9. Cell with rhabdites, camera lucida, X 100.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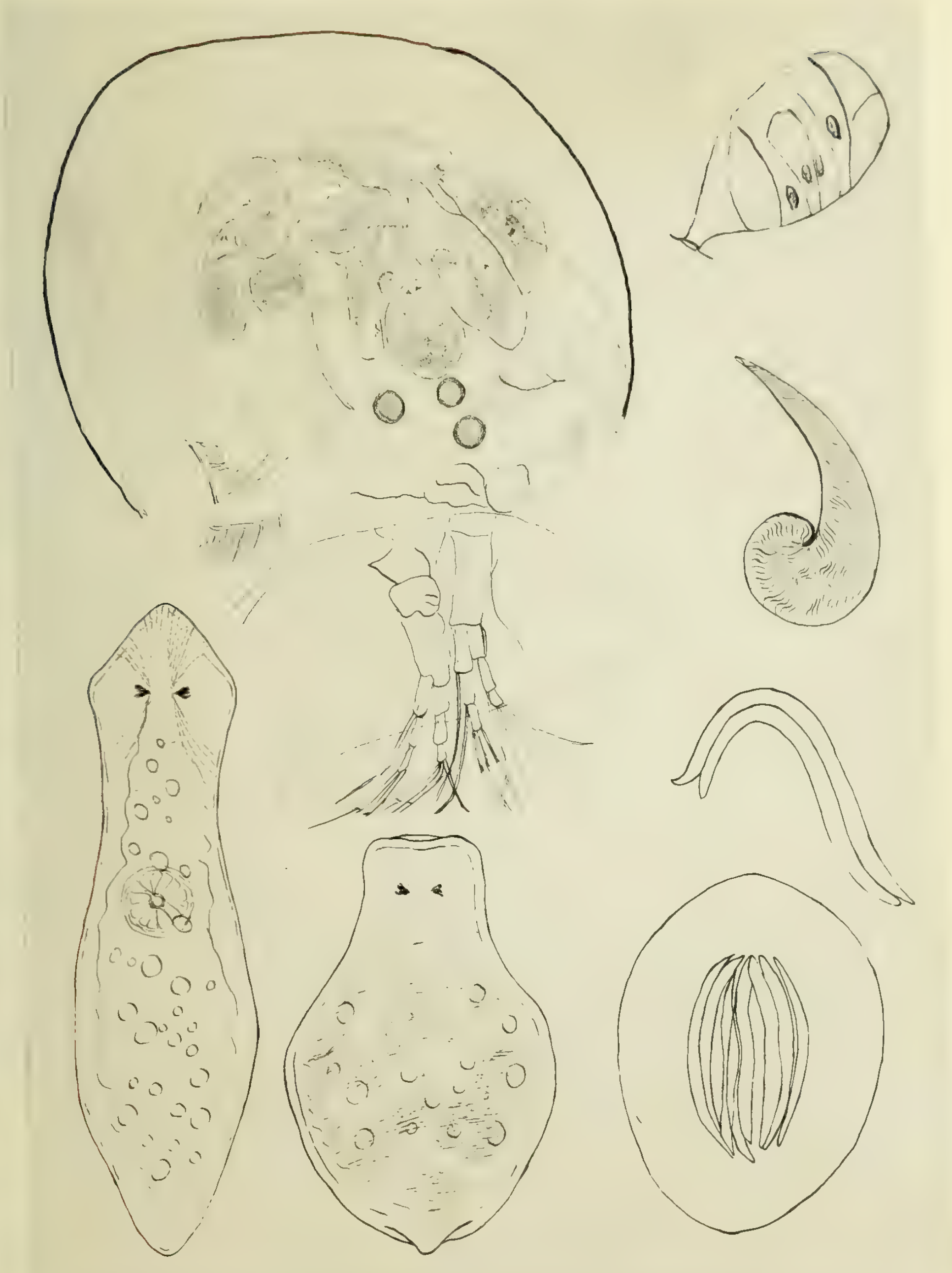


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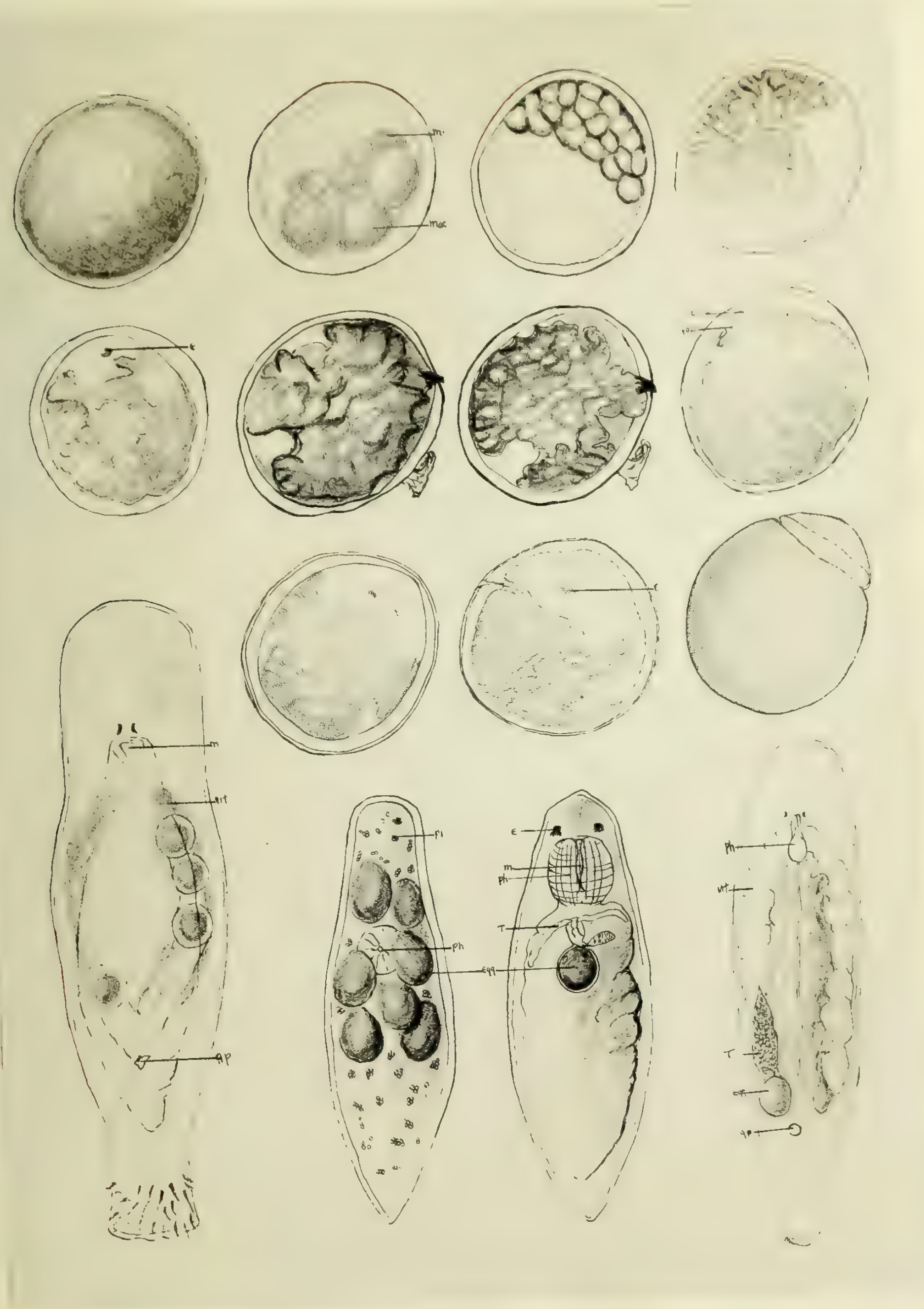
PLATE III



Explanation of Plate IV

Fig. 25. Reproductive organs of Dalyellia alba, x about 200.

Fig. 26. Protonephridium of Dalyellia alba, X about 350.

Fig. 27. Rhabdites of Typhloplana viridata, one in cell. Camera lucida, X 350.

Fig. 28. Eye of Dalyellia alba, X about 200.

Fig. 29. Tail region of Mesostoma ehrenbergii, X about 100.

Fig. 30. Rhabdites of Typhloplana viridata. Camera lucida, X 350.

Fig. 31. Rhabdites of T. viridata, old cell, X about 350.

Fig. 32. Tail region, Mesostoma simplex, X about 100.

Fig. 33. Rhabdites in cell, Mesostoma alba. Camera lucida, X 150.

Fig. 34. Vitelline gland cell, showing stored oil globules, X about 250.

Fig. 35. Ovary of Mesostoma alba, X about 350.

Fig. 36. Cirrus sac, Mesostoma alba, X about 350.

Fig. 37. Testis, Mesostoma alba, X about 350.

Fig. 38. Rhabdites in cell, Mesostoma alba, X about 200.

Fig. 39. Eye, Dalyellia alba, X about 175.

Fig. 40. End view of rhabdite-bearing cell of Mesostoma alba, X about 350.


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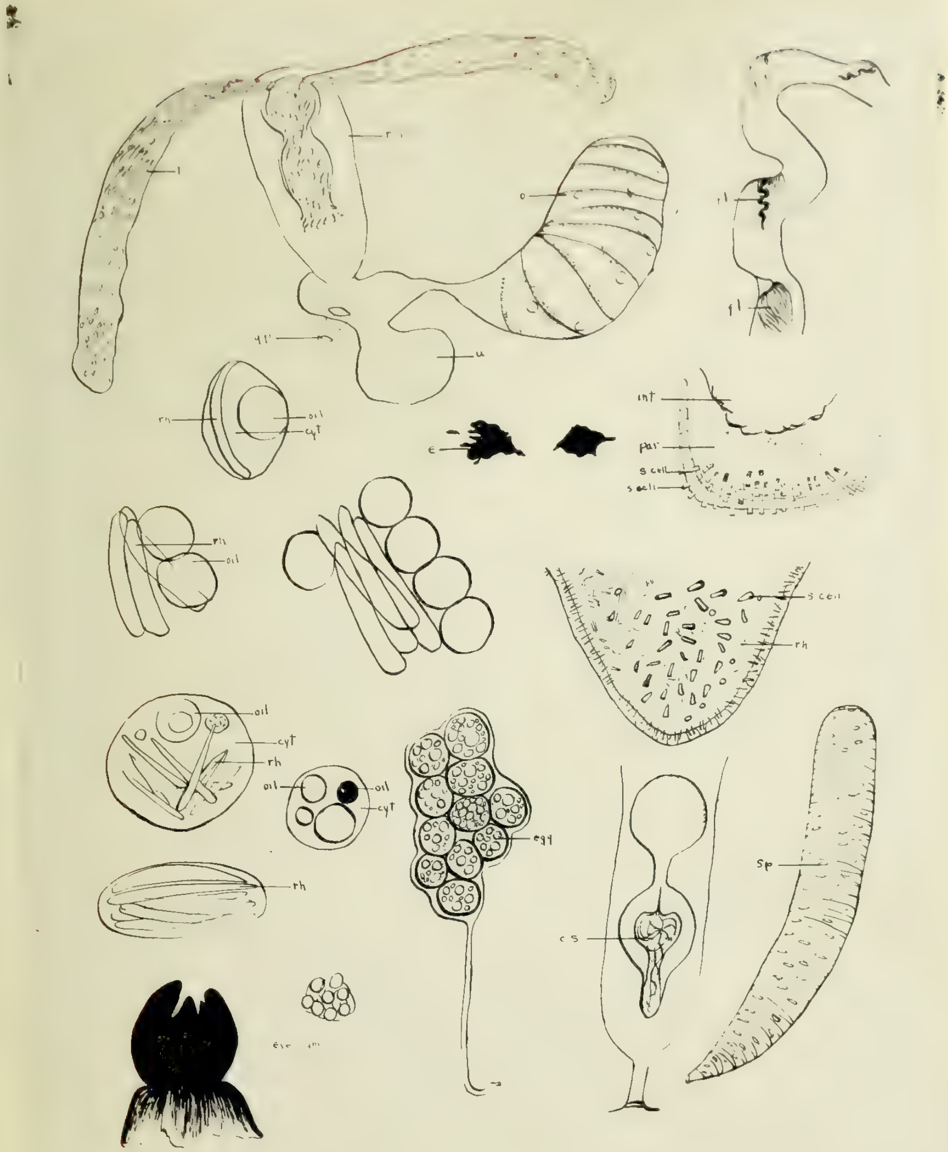
PLATE IV



Explanation of Plate V

Fig. 41. *Mesostoma ehrenbergii*, lateral view, slightly compressed, x 50.

Fig. 42. *Mesostoma simplex*, slightly compressed, X 40.

Fig. 43. Eyes of *Planaria maculata*, X about 100.

Fig. 44. Eyes of *Planaria maculata minor*, camera lucida, X 100.

Fig. 45. Uterus of *Mesostoma ehrenbergii*, showing young worms and eggs just ready to hatch, X about 50.

Fig. 46. Section thru fission plane of *Stenostomum giganteum*. Camera lucida, X 150.


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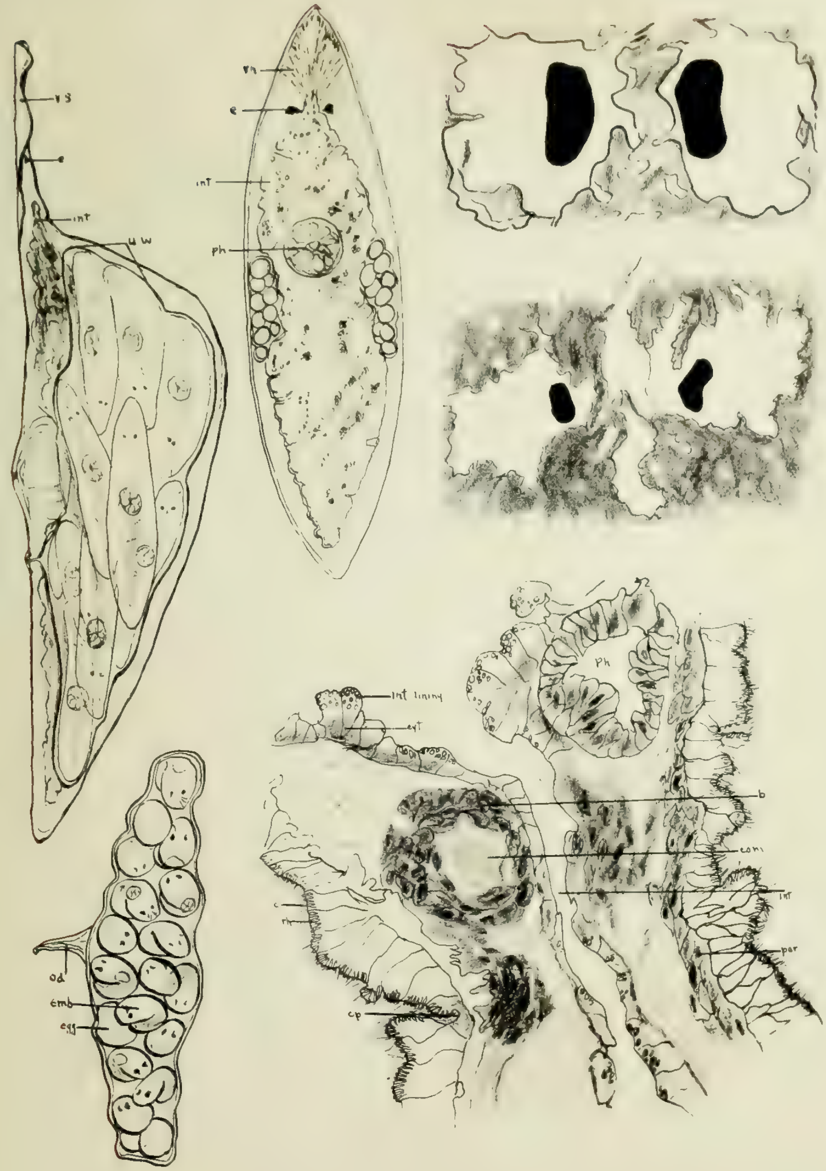
PLATE V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Explanation of Plate VI

Fig. 47. *Stenostomum glandifera* nov. spec. dorsal view, slightly compressed, X about 120.

Fig. 48. *Stenostomum giganteum* nov. spec. lateral ~~dorsal~~ view, slightly compressed, X 100.

Fig. 49. Head of *Dalyellia dodgei*, antero-dorsal view, showing elevated mouth. X about 100.

Fig. 50. Head of *Stenostomum leucops*, pharynx closed, X about 100.

Fig. 51. Head of *Stenostomum leucops*, pharynx open, X about 100.

Fig. 52. Nematocyst of *Microstomum caudatum*, X about 850.

Fig. 53. Lateral view of head of *Microstomum caudatum*, X about 100.

Fig. 54. *Dalyellia fusiforma*, dorsal view, slightly compressed, X about 90.

Fig. 55. Transverse section, *Mesostoma ehrenbergii*, showing folds of body wall. Camera lucida, X 250.

Fig. 56. Ventral view of head of *Microstomum caudatum*, X about 100.

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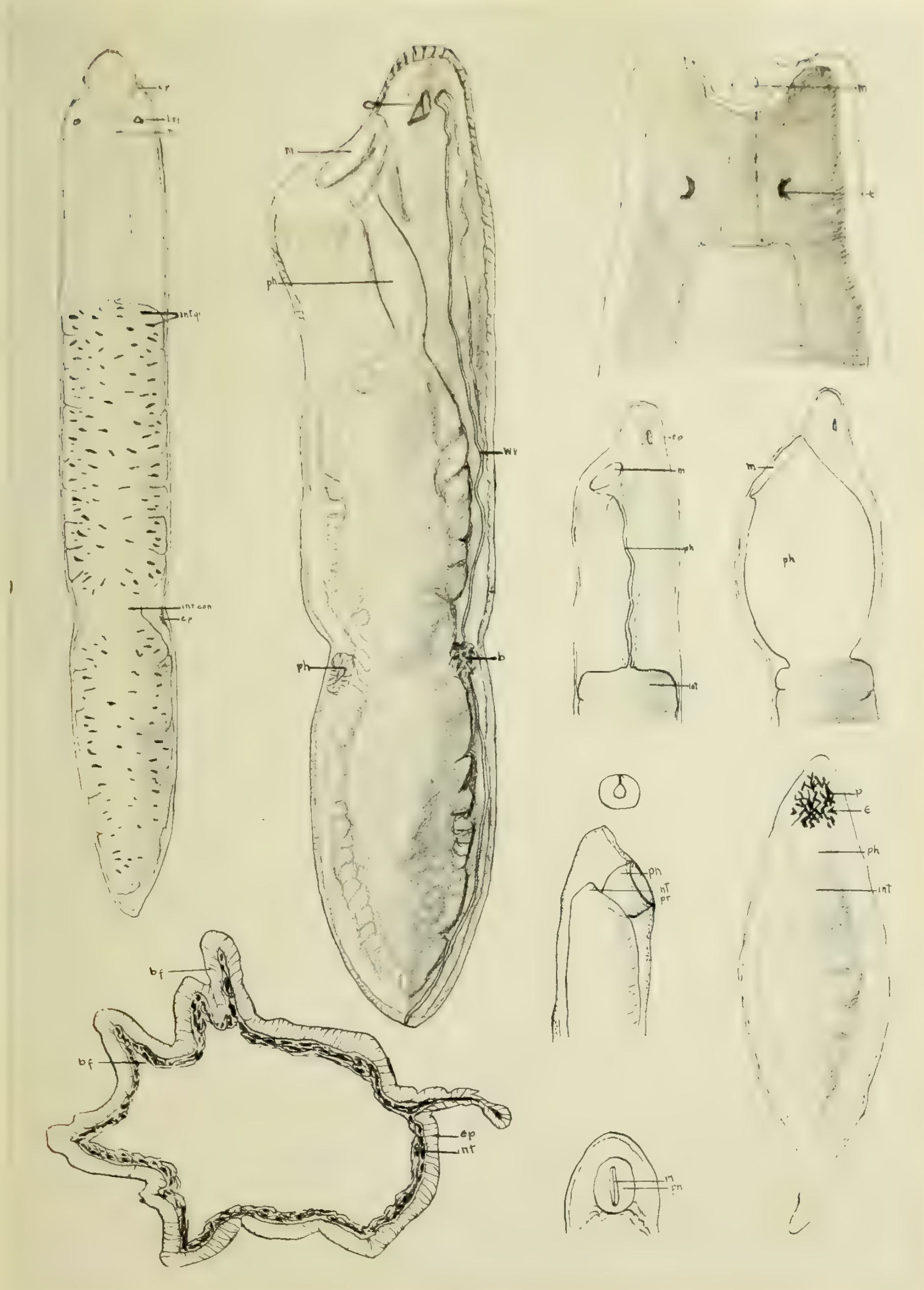
PLATE VI



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