XII. "Contributions to the Anatomy of the Hirudinea." By Alfred Gibbs Bourne, B.Sc. Lond., University Scholar in Zoology, and Assistant in the Zoological Laboratory, University College, London. Communicated by Dr. M. Foster, Sec. R.S. Received June 21, 1883.

(Abstract.)

The author has investigated the following genera:—

Rhyncobdellidæ.—*Pontobdella*, *Piscicola*, *Clepsine*, *Branchellion*.

Gnathobdellidæ.—*Aulostoma*, *Hæmopis*, *Hirudo*, *Hæmadipsa*, *Nephelis*, *Trocheta*.

The author gives a bibliography of the most important literature upon the group since the appearance of Moquin-Tandon's monograph.

External Characters and Evidences of Segmentation.

The author, in attempting to answer the question—How far in the series of Hirudinean genera do external characters express the metamerically segmented nature of their organisation?—follows in the footsteps of Gratiolet and Vaillant, who have dealt with *Hirudo* and *Pontobdella* respectively in this connexion. The further question—How far do such metameres represent the somites of a bristle-bearing worm?—first suggested itself to the mind of De Quatrefages.

The author shows that these external evidences of metamerism in *Pontobdella* are most complete, and further that they have a precise relation to the metamerism expressed by the internal organisation. The normal somite here presents four annuli of varying size, each with its special and distinct arrangement of papillæ.

The clitellum involves two reduced somites, each consisting of two annuli, the generative pores being placed between these respectively. The nerve-cord exhibits a corresponding condensation in this region. Twenty somites can be readily distinguished, while posteriorly there are indications of several others, which is in accordance with the existence of twenty-three post-oral ganglia and with Leuckart's observations (*Hirudo*) upon the condensation of an even greater number of primitively separate ganglia in this region. They are rudiments of originally existing somites.

In *Branchellion* it may be shown that three annuli comprise the somite, that in the median region, while every annulus bears a branchia (lateral appendage), the most anterior annulus of the somite bears a vascular dilatation at the base of its branchia.

Similar dilatations, although in a more rudimentary condition, exist in a similar position in *Piscicola*, *Clepsine*, and *Pontobdella*.

In *Hirudo* the external evidences of metameric segmentation are not so pronounced, but minute examination shows that point for point *Hirudo* agrees almost absolutely with *Pontobdella*. The somite comprises five annuli, the clitellum three somites, the generative pores being placed in the two more posterior.

There is an absolute regularity in the position of the nephridal pores, these occurring in the posterior annulus of a somite.

The internal organisation bears the same relation to these external characters which was stated to obtain in *Pontobdella*. The similar characters of other genera are less fully dealt with.

The external characters thus express in the fullest manner the metamerically segmented character of the internal organisation, and these relations are identical throughout the group.

Skin.

The skin consists of—

1. Cuticle.
2. Epidermis.
3. Dermis.

Cuticle.—This presents similar characters throughout the group.

Epidermis.—This consists throughout the group of a single layer of nucleated cells. These vary in size in different genera.

Two varieties of connective tissue may intrude upon the series of epidermic cells:—

1. Pigmented connective tissue cells, and
2. Capillaries of the vascular system.

No pigment is ever developed in the epidermic cells themselves, as is the case in *Peripatus* (Balfour). The extent to which this intrusion takes place (in respect of the pigmented tissue at any rate) varies much in genera and species, and even in individuals. In most leeches it varies also from point to point, producing the coloured pattern upon the surface of the body.

The intrusion of capillaries only takes place in the Gnathobdellidæ; in the Rhyncobdellidæ they stop short of the epidermic series of cells or merely insert themselves between the bases of these cells.

Two modifications of epidermic cells may take place—*

1. They may become glandular.
2. They may become sensory.

1. *Epidermic Glands.*—Two kinds of epidermic glands are to be distinguished.

i. Mucous glands.—These remain dermic in position and occur all over the surface of the body. They may remain small, and in the series of epidermic cells not passing below them (*Piscicola*), or

* The author takes no account here of the origin of the nephridia; they may be, however, glandular modifications of epidermic cells, but if so are much specialised.

becoming larger, they acquire a narrow neck and lie in the dermic layer of the skin.

They attain a larger size among the Rhyncobdellidæ than among the Gnathobdellidæ, becoming immense in *Branchellion*.

ii. Glands which have taken up a "deep" position among or even within the muscular bundles. They present three well marked varieties.

a. Salivary Glands.—These occur in all the genera, in the region of the pharynx, whether that be protrusible or not. In the former case they open directly into its lumen, in the latter their ducts enter into its base and open along its extended lumen. When the pharynx is protruded they are much stretched, when withdrawn, thrown into folds.

β. Clitellar Glands.—These appear to occur in all the genera except Clepsine, in which genus no cocoon is formed for the eggs. They are exceedingly abundant. In the Rhyncobdellidæ, *Piscicola*, *Pontobdella*, and *Branchellion* they occur even far back in the body, and send their ducts forward in bundles to open upon the surface of the clitellum.

γ. Prostomial Glands.—The author has observed this variety in *Hirudo*, *Aulostoma*, *Nephelis*, and *Trocheta*. They form clear contents and send ducts forwards to open upon the prostomial region. They occur all round the mouth, but in great number in the prostomium. The author has not been able to determine their function.

2. *Sensory Cells.*—The author has not dealt with this modification of epidermic cells. Leydig has given full descriptions of these and their derivatives.

Dermis.—This lies between the epidermis and the circular muscles of the body-wall.

It consists of a matrix of connective jelly (for these and other terms with regard to the connective tissues the author is indebted to a paper by Professor Lankester "On the Connective and Vasifactive Tissues of the Medicinal Leech"), in which are to be found the various forms of connective tissue cell described below, numerous and large blood-vessels, and short muscular fibres.

The muscular fibres are not found in *Clepsine*, *Nephelis*, or *Trocheta*.

The lateral appendages in *Branchellion* are dermic developments.

All the connective and vasifactive elements in the dermis, form a packing to the mucous glands of the epidermis.

Muscles.

The author describes the general arrangement of the muscles, recognizing—

Muscles of the body-wall.

Dorso-ventral and radial muscles.

Muscles in the wall of the alimentary canal.

With regard to the pharynx and its muscles, the protrusible pharynx of the Rhyncobdellidæ is to be regarded as representing the whole body in that region, rather than as merely a central region; when protruded it is in fact an anterior portion of the body. The manner in which it protrudes and recedes into a temporary sac would suggest this, but comparison between its structure and the structure of the whole anterior portion of the body in the Gnathobdellidæ shows that such is the case. This can only be made clear by a series of figures which the author gives.

Muscles developed in the walls of blood-vessels.

Muscles developed in connexion with the generative glands.

Muscles in the walls of the vesicle of the nephridium.

Muscles developed in the skin.

Histological Characters of the Muscles.

The muscles are formed of elongated cells arranged either in bundles or lying singly.

These cells may be much branched; such branched cells occur upon the wall of the alimentary tract, and among the dorso-ventral muscles. The cells consist of a cortical and medullary substance, greatly differentiated from one another. The medullary substance is granular and lodges a large oval nucleus in all cases.

Connective and Vasifactive Tissue.

The author has worked out the histology of the connective substance, and traced its various metamorphoses throughout the group.

The matrix consists of a jelly-like substance, which varies much in amount in different genera; its amount determines the "limpness" or rigidity of the leech. *Hæmopis* and *Aulostoma*, whose bodies are always "limp," possess a great quantity, while *Clepsine* and *Nephelis*, whose bodies are rigid, possess very little.

In the matrix are embedded indifferent corpuscles.

The corpuscles undergo certain metamorphoses:—

1. Entoplastic metamorphosis—the cell preserving a rounded form —Vacuolated cells—Fat cells.

A semi-fluid substance accumulates in droplets in the cell, giving it a reticulately vacuolated appearance; such cells resemble Waldeyer's plasma cells. They are very common in *Pontobdella*.

Fat globules also accumulate, and running together form fat cells, similar in character to the fat cells of Vertebrata. This occurs in *Clepsine* and *Piscicola*. This substance formed presents all the characters and reactions of fat.

Rounded connective tissue-cells are rare among the Gnathobdellidæ, *Trocheta* being the only genus which presents such. They occur in masses, and are also very generally arranged in rows, probably prior to their conversion into botryoidal tissue.

2. Ectoplastic metamorphosis—the cells forming fibres.

The cells of most wide-spread occurrence are cells which have elongated, and it may be branched and formed fibres.

It is possible to trace this process; a slightly irregular cell elongates more and more, and its processes become drawn out, so that ultimately little cell-substance is left and a long very fine fibre is produced, the cell all the time doubtless adding to matrix.

In *Pontobdella* these fibres may become elastic. They always run singly.

3. Ect-entoplastic metamorphosis—the cell developes pigment.

a. The cells take no part in the formation of a vascular system.

This series of modifications is well seen in *Pontobdella*. Indifferent cells develope pigment; this may be traced, originating in young animals (recently hatched).

Such cells either remain rounded or they divide into irregular groups, and afterwards become much branched. The process may be shortened, the cell branching, and forming pigment simultaneously.

The rounded cells lie more deeply, the branched cells lie more superficially, and form the pigment of the dermis.

β. The cells take part in the formation of a vascular system—Botryoidal tissue—"Vasofibrous" tissue.

A set of modifications similar to those just described takes place, but intracellular vacuolation taking place at the same time vascular spaces are formed. These come in communication with the capillaries of the true vascular system on the one hand, and with the sinuses on the other.

4. Entoplastic metamorphosis—Vacuolation to form Capillaries.

The capillaries of the true vascular system are probably formed by the vacuolation of indifferent connective tissue cells.

It may be noticed here that in forms where no canalisation of pigmented cells has occurred, the blood is always colourless, while in forms with red blood such canalisation of pigmented tissue has occurred in the formation of the vascular system.

Blood and Blood Spaces.

Blood.—In the Rhyncobdellidæ—

The blood is colourless.

Colourless amœboid corpuscles occur in very large numbers, but present no remarkable histological characters.

In the Gnathobdellidae—

The blood is red, the plasma containing dissolved hæmoglobin.

Colourless amœboid cells certainly occur in large numbers. In *Nephelis* and *Trocheta* these are almost as large as in *Pontobdella*.

In *Hirudo* and *Aulostoma* these, although not so large, undoubtedly exist in large numbers, in addition to free nuclei.

The blood in all the genera coagulates rapidly when withdrawn from the body, filaments of fibrin or some allied substance can be seen forming on the slide.

Blood Spaces.—These belong to two different systems, which are, however, in direct communication, there being only one fluid. The author shows that one system represents the closed vascular system, while the other represents cœlom, vessels, and sinuses.

The vessels may, to a certain extent, be distinguished by their muscular walls, the walls of the sinuses not being muscular.

Communications between these two systems of spaces, vessels and sinuses exist only at certain definite spots, as in the Rhyncobdellidæ; the vascular dilatations at the sides of the body which are most fully developed in *Branchellion* affording means of communication; or else the spaces establishing that communication, although very numerous, have a special mode of formation and a special nature, such spaces constitute botryoidal tissue (Gnathobdellidæ).

The author describes at length the distribution of the vessels and sinuses.

The conclusion at which the author has arrived concerning the cœlom in the Hirudinea may be thus summed up:—

The somewhat scanty embryological evidence which exists upon this point favours the view that the cœlom developes by a splitting in the mesoblast; that it is, in fact, that modification of an enterocœle which Professor Huxley has termed a schizocœle.

This cavity persists to some extent in all the genera, and while it remains most fully developed in the Rhyncobdellidæ, it is reduced to a minimum in *Nephelis* and *Trocheta*, being then represented only by the ventral sinus and its immediate branches.

In the Rhyncobdellidæ, at any rate in *Clepsine*, *Pontobdella*, and *Branchellion*, the cœlomic remnants (sinuses) continue to be lined with cœlomic epithelium cells. In many places they form a continuous layer, but generally some of them have become free and are to be seen floating in the blood. These free cœlomic epithelium cells, which are much larger than the ordinary blood corpuscles, are only to be seen in the sinuses; they are probably too large to pass through the communicating channels. In the Gnathobdellidæ there is no trace of such cells.

A process has been taking place, which the author proposes to term *diacœlosis*—a "scattering of the cœlom"—connective tissue growths having more or less completely filled it up, the remnants forming the sinus system. Different remnants remain in different genera.

The organs which, in animals possessing a well-developed cœlom, lie within that cœlom, either get blocked out by connective tissue growth or remain enclosed in the remnants. The same organs may remain in different remnants in different genera. No better instance can be given of this than the varying position of the nephridial funnel in *Clepsine*, *Pontobdella*, and *Hirudo*.

The lumen of the existing cœlom, as above described, comes into communication with the lumen of a true vascular system, which was probably either derived at a very early period from the archaic enterocœle, or was formed independently by hollowing in connective tissue cells. That the communication between the two is of a secondary nature, and not a persistence of the original communication, which must have existed if one developed from the other, is indicated by the existence of colourless amœboid cells in the ovarian sac and around the vas deferens in *Hirudo*. These were probably closed at a very early period before the development of hæmoglobin. This may have a phylogenetic bearing only, but it may very possibly be a process which is repeated ontogenetically.

The development of new cœlomic space (botryoidal tissue) may be termed *pseudocœlosis*.

That this new space is "cœlomic" is amply demonstrated by the fact that in its highest development it encloses the nephridial funnel (*Nephelis*), and, further, that such perinephrostomatous portions of it may acquire a definite musculature and the "botryoidal" cells become modified to form a secondary cœlomic epithelium. The interpretation which the author would put upon this process is that an archaic enterocœle gradually undergoes diacœlosis, being replaced by a pseudocœle. This primary and secondary cœlom exist simultaneously side by side in all existing Gnathobdellidæ.

In the Rhyncobdellidæ considerably more of the primary cœlom remains, and the secondary cœlom has not yet appeared upon the scene.

Nephridia.

The nephridia are in all cases tubular organs, opening on the one hand into the cœlom, and on the other to the exterior.

The funnel, the opening to the cœlom, exists in all the genera, although its existence in *Hirudo* and allied genera has always been denied, but it has long been known to exist in *Clepsine*, *Nephelis*, and had also been described in *Pontobdella*.

The condition of these funnels presents a serial modification. In *Clepsine* and *Pontobdella* they are fairly simple, but in *Nephelis* and *Trocheta* they become drawn out into lobes, and in *Hirudo* and its allies this process has been carried to an extreme, the central lumen

has become lost, and the whole has become a many-lobed, ciliated, spongy mass.

Following upon the neck of the funnel is a dilatation into which blood corpuscles are carried by the ciliary current. In *Hirudo* and its allies the ciliated mass above described comes to surround this.

The position of this funnel varies:—

in *Clepsine* it opens into the ventral sinus;

in *Pontobdella* into special perinephrostomatous sinuses;

in *Hirudo* and *Aulostoma* into remnants of a circumtesticular sinus;

in *Nephelis* and *Trocheta* into botryoidal spaces (pseudocœlom).

The portion of the gland which follows upon the funnel exhibits a degenerate condition; this is probably to be accounted for by the fact that the funnel is gradually losing physiological importance, its function in regard to the secretion of nitrogenous waste being taken on by the blood-vessels. Those genera in which the funnel remains best developed exhibit but little capillary development, and *vice versâ*.

Following upon the degenerate portion or testis lobe is a portion with numerous cells containing branched ductules; these collect together and a central duct is formed, which after a long and winding course either opens directly to the exterior (*Clepsine*), or into a space which then opens to the exterior.

The lumen is throughout intracellular in origin.

This description, excepting as regards the funnel, does not apply to *Pontobdella* or *Piscicola*.

The author describes as existing there a most curious network of tubules, apparently continuous throughout the body and not segmented. These tubules are exceedingly small, and their continuity is a very difficult point to determine with certainty.

These tubules are arranged very irregularly, they turn, twist, bend upon themselves, and anastomose with one another in a most elaborate manner. Their walls become very thin at parts, but never present any opening. The walls present a rod-like structure, such as exists in the nephridial cells in other genera. The lumen is intracellular, the cells being much branched and very large.

The author has been unable to trace their connexion with the funnels, or with a series of very rudimentary vesicles, but such a connexion probably exists. The author has also been unable, owing doubtless to the roughness of the skin, to see the external apertures; he has, however, seen them in *Piscicola*, where a similar structure obtains.

The author proposes to reserve any general conclusions as to the systematic position of the *Hirudinea* which may be drawn from these facts for another communication.