2. Notes on the Clitellum of the Earthworm.

By Frank J. Cole, Physiological Laboratory, University of Oxford.

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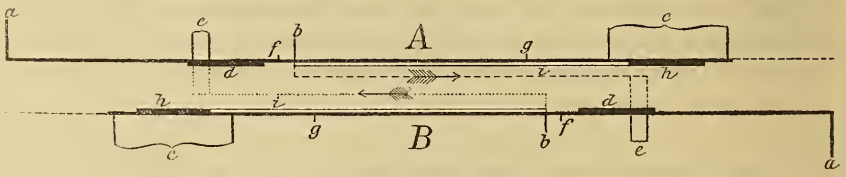
It is as well to preface these notes with a brief discussion of the copulation of the earthworm, with which the clitellum seems to have some connection. Many theories as to the precise character of this process in the earthworm have been advanced, but as they nearly all contain obvious and vital discrepancies, it is only necessary to consider the views which have comparatively recently been advanced. These may be considered to have been fairly weighed and presented in Vogt and Yung's »Comparative Anatomy«, and I therefore reproduce the description these authors give in their magnificent text-book, as the best and most accurate account yet published. I quote from the French edition, p. 476:

»Durant la copulation, les deux vers s'appliquent l'un contre l'autre par leur face ventrale, en se renversant de telle sorte que la tête de l'un est dirigée vers la queue de l'autre, et que les orifices génitaux sont réciproquement en contact avec la ceinture. Le sperme éjaculé sous forme de petites masses blanchâtres se moule en courts cylindres dans deux rigoles longitudinales formées par une dépression des téguments et coule ainsi jusqu'à la ceinture pour passer de là dans les poches séminales. Les deux vers sont réunis alors par un anneau de mucosité sécrété par la ceinture et peut-être aussi par les glandes accessoires [capsulo-genous] dont nous avons signalé la présence dans le voisinage des organes génitaux. Les oeufs pondus à travers les orifices des oviductes arrivent à la ceinture où ils sont enveloppés de mucus dans lequel on aperçoit des zoospermes, et qui leur constitue une capsule de forme ovoïde.«

In criticising this, the following diagram, which has been carefully drawn to scale, will be of some assistance:

Fig. 1.



L. herculeus. *a* Head extremity. *b* Orifice of vas deferens. *c* Extent of clitellum (segments 32—37). *d* Extent of capsulo-genous glands (segments 9—13). *e* Orifices of Spermathecae. *f* Orifice of oviduct. *h* Extent of tubercula pubertatis (segments 33—36). *i* Seminal duct.

The two worms *A* and *B* are opposed ventrally, the head of the one being directed towards the tail of the other. At least three means are employed in the union: 1) The clitelline setae (see below); 2) the secretion of the clitellum itself; 3) the capsulo-genous glands. These are matters of actual observation. It is probable, however, that other means may be occasionally used. For example, Dr. Hurst informs me that »a belt, apparently cuticular, arising from the papilliform enlargements placed ventro-laterally in segment XXVI [*g* in fig.], of each worm surrounds the body of the other.«

The worms, being united (particularly by a strong band secreted by the clitellum), an exchange of seminal fluid takes place — that is to say, both worms discharge the contents of their seminal vesicles (see the dots and dashes in fig.). According to Vogt and Yung, the semen now streams down to the clitellum in furrows formed by longitudinal depressions of the integument, converted into ducts by the opposing surface of the other worm. Having arrived at the clitellum, it passes into the spermathecae, the orifices of which are placed against the clitellum (the anterior end?). It is obvious that the discharge cannot be simultaneous, as the positions of the two sets of furrows would to a great extent be identical. But this is unimportant. Further the furrows, though clumsy, have this much to be said for them; viz. that, on account of the waste involved, their existence would explain the large development of the seminal vesicles, which certainly attain an inordinate size. Also, they would prove an interesting corollary to conclusions to be derived from a study of the genitalia of the earthworm, inasmuch as their rough simplicity would be an excellent example of the temporary expedients adopted by nature in effecting »extensive morphological alterations«. Nevertheless it seemed to me that their existence must be doubted, and was confirmed in this by what I observed recently.

Whilst examining a very large number of worms, I came across two (both *A. longa*) which had external ducts connecting the orifices of the vasa deferentia in the 15th segment with the clitellum, and communicating with the tubercula pubertatis (see fig.). These ducts (which I shall call »seminal ducts«) seemed to consist merely of very narrow longitudinal inflations of the cuticle; but whatever their precise nature, there could not be the slightest doubt of their presence, for they were to be clearly seen in the living animal. On cutting sections, however, I was disappointed to find only doubtful traces of the canals, and they certainly contained no sperms, although I stained some sections for them. If, as I suppose, the seminal ducts are only fragile evaginations of the cuticle, it is easy to explain how,

in a complicated paraffin method, they may have collapsed. As I only found them in two individuals out of some hundreds of others, it is not probable that more will be readily obtained; but if one were carefully examined under a dissecting microscope, and the contents of the ducts stained for spermatozoa, it would easy to decide the matter. Frozen or celloidin sections could also be made. The function of the seminal ducts would obviously be that of receiving the contents of the seminal vesicles from the orifices of the vasa deferentia in the 15th segment (which would in that case not open on to the exterior, but under the cuticle), and of conveying them to the clitellum. The connection between the ducts and the tubercula pubertatis, whilst it seems to imply that the spermathecal orifices would be placed against the centre of the clitellum, and not, as now supposed, at the anterior end of it, may also serve to give us a clue to the function of the latter. This may be either that of aggregating the sperms into spermatophores — thus assigning to the spermathecae a storing function only — or that of »cementing« the ducts to the orifices of the spermathecae, in order to prevent a waste of seminal fluid. Both these conjectures, however, are improbable, and the tubercula pubertatis must for the present remain a puzzle. For the rest we can understand that, with the seminal ducts, the exchange of seminal fluid could be simultaneous — which is what probably happens.

With the spermathecae full of spermatophores, it now becomes a question of fertilization and of the cocoon. The remainder of Vogt and Yung's description, which deals with this, is open to the gravest objections. The *alors* cannot mean that the cocoon is formed immediately after copulation, as that would not only involve the greatest difficulties, but would contradict matters of very common observation; nor is there less difficulty in understanding them to imply that it is elaborated at a totally distinct union (*réunis*), taking place some little or greater time after. For how could the contents of almost microscopic bodies traverse from the 14th segment to at least the 32nd, down rough channels and without ciliary action. It is easy to understand the steady accumulation of the male element in the seminal vesicles, because a flow must be necessary in order that any of it should reach the clitellum. But we have no such development in connection with the ovaries, excepting of course the very small receptacula ovorum, and hence the difficulty. Further, let us suppose that the worms *A* and *B* in the fig. have just copulated, i. e. that an exchange of sperms has been effected. Now the only thing necessary in the case of each, is that their eggs should be fertilised by the sperms already received. Vogt and Yung can see no other method of doing this than that of calling

in the services of still another worm for each — since Darwin's work teaches us that it would be the merest chance if, after the time that elapses between copulation and oviposition, the same worms were united again. Hence a second coition is rendered extremely improbable, whilst it certainly is not necessary to explain the phenomena. Therefore it seems to me that this generally accepted explanation must be almost entirely abandoned.

The formation of the cocoon must of course be a matter for observation, and as such I can add nothing to the little already known. Some general observations, however, may be of service. First, I have difficulty in believing that the clitellum secretes the cocoon, for these reasons: 1) That, on this assumption, its position, 17 segments behind any trace of reproductive organs, is inexplicable. It is not sufficient to say that my own diagram clears this up by illustrating its important functions in copulation — that would savour of the mountain coming to the prophet. For if the clitellum were say 10 segments for the forward, it would still answer all the purposes of copulation, and undoubtedly gain in the secretion of the cocoon. I think that, considering probabilities, it must be admitted that the position of the clitellum points to the conclusion that its only office is to meet the exigencies of an otherwise difficult copulation. To effect this, it was necessary that it should be somewhere behind the genital organs, in fact in much about the same position that we find it now; but if it had been intended to have performed the double function, then we should have expected it to have been nearer the reproductive organs, and not to have lost more than it gained by being farther back. 2) That if the clitellum does secrete the cocoon, then it is only slightly developed, and sometimes its characteristic features are altogether wanting, in precisely that part where it should be most highly developed — in the ventral region. That therefore the cocoon should have an uneven texture. 3) It would be necessary to explain how it was peeled off over 32 segments, and against the resistance of the setae, and how the ends were closed up. 4) With reference to the former, I may say that it is supposed to be worked off by longitudinal contractions of the body, and to the latter that the ends are believed to be twisted and not sealed.

But if the clitellum does not secrete the cocoon, we must consider what does. My belief is, although I am not yet in a position to establish it, that the capsulo-genous glands do this work. Their position to a great extent suggests this function, and if they extended to the 14th segment, there would be strong a priori grounds in favour of the assumption. My idea of the process is this: after copulation (how long?), the glands secrete a cuticular sheet of mucus, in which calcium salts

are deposited, and which extends on the ventral surface of the genital region only so far as to embrace the orifices of the spermathecae and the oviducts. Note that this is about 5 segments, and that the mean size of the cocoon corresponds roughly to the length of these 5 segments. The sheet, adhering at its edges, is then made bulge out by the contraction of the body, and the ova and spermatophores are deposited through the orifices of the oviducts and spermathecae respectively. Another sheet is then secreted, and cemented to the edges of the first and the cocoon thus formed set free by the contraction of the longitudinal and transverse muscles of the integument. This simple process, or one similar to it, as seems to me, is what we must expect to find, but whatever is found, it is to be hoped that a provokingly complicated problem will soon be cleared up.

The following description of the histology of the clitellum applies to *L. herculeus*.

The glands are very largely developed dorsally and dorso-laterally, and only slightly — sometimes not at all — ventrally. They are first formed in bunches, and this gives externally a peculiar convoluted appearance to the organ. A transverse section shows that the body wall is surrounded by a delicate cuticle, iridescent by virtue of the fine striae dividing it into little squares, which have a decomposing effect upon light. Dr. Hurst doubts this cause of the iridescence, assigning it to the thinness of the cuticle; but I doubt whether the cuticle is not too thick to produce iridescence, and it certainly is in *Allolobophora*. Next the cuticle are situated the glandular layers, which will probably be found represented in the ventral region. In connection with this, it would be noticed that the longitudinal muscular layer has an increase proportionate with the decrease in the clitellum. This curious fact, which was first noticed by Claparède[1], I endeavoured to explain by the conjecture that the longitudinal muscles atrophied dorsally in order that the secretion of the glands might not be affected by any violent expansion or contraction of the body wall in this region. The surmise, however, was not altogether justified by the movements of the living animal. It now appears to me probable that this ventral muscular development is in connection with what Vogt and Yung[2] call *les soies copulatrices*, or the setae acting as claspers that were first observed be Hering. Perhaps the irregularity may more accurately be described as normal ventrally and degenerate dorsally. The normal

[1] Histologische Untersuchungen über den Regenwurm. Zeitschr. f. wiss. Zool. t. XIX, 1869.

[2] P. 476.

persistence dorsally is not required and the muscle atrophies there in order that the body wall may not be inconveniently thick.

A fact connected with the muscular layers, which has hitherto been unnoticed, is that the longitudinal layer is sometimes external to the circular layer. When this obtains (I have noticed it in about 6 of my specimens), both layers vary from the normal type. The longitudinal layer is no longer, or only slightly, bi-pinnate (see fig. 2), and is divided into two parts. The outer retains some similarity to the usual form, but has much stouter fibres; whilst the inner has each fibre surrounded by a muscular sheath, so that the appearance is presented of large cells with prominent irregular nuclei. The outer predominates dorsally, and the inner ventrally, but sometimes there is only one layer dorsally and one ventrally. The circular layer is always enormously developed. It is difficult to see how these occurrences can be regarded as individual variations, and although all were carefully identified as *L. herculeus*, I suspect that the differences are specific, and that, when the various species of earthworms are all carefully examined with the microscope as well as with the naked eye, some more species will have to be created.

The following measurements illustrate the relative thicknesses of the respective layers, the ratio of one layer towards another being fairly constant:

Zeiß, oc. Microm. 3, obj. a_2.

1.	Dorsal to chord	clitellum, including cuticle	·65	mm
		longitudinal muscular layer	·075	»
			·725	»
	Ventral to chord	clitellum	·15	»
		longitudinal muscular layer	·4	»
			·55	»
2.	Dorsal to chord	clitellum	·5	»
		longitudinal muscular layer	·1	»
			·6	»
	Ventral to chord	clitellum	·1	»
		longitudinal muscular layer	·3	»
			·4	»

The circular layer, though more variable, also has its greatest development ventrally:

1.	Dorsal	·05	mm
	Ventral	·1	»
2.	Ventral	·2	»
	Dorsal	·05	»

Next to the cuticle there is a very well-marked layer, and here, as in fact upon almost all points, I have to differ with Claparède. He states (pp. 576—7) that the clitellum is strictly merely a characteristically modified part of the integument, and his reasons for saying this are that he found in it the various layers and structures present in normal integument. After this it is curious to find him stating that the most prominent part of the clitellum (i. e., the glands *d*, Fig. 2) has nothing corresponding to it in the hypodermis, and that his vascular layer is also peculiar. It is evident that he failed to recognise the true relationship of the clitellum to the hypodermis.

Claparède figures (Plate 46, Fig. 1) three elements in the second, or first glandular, layer; viz., 1) hypodermic cells; 2) intercellular spaces; and 3) the necks of the *prolongements glandulaires*, or the »[modified] unicellular cutaneous glands« as they are known to English anatomists, and which, in the region of the clitellum, I shall hereafter call the calceo-cuticular glands, because they supply the cuticular matrix in which the carbonates are deposited, and not because they themselves secrete the carbonates, or are in any way morphologically distinct from hypodermic cells. I have found no hypodermic cells in the clitellum — a very significant fact which I shall consider later on. It is very interesting to cut sections of developing clitella, and to notice how the hypodermic cells disappear proportionately as the clitelline glands mature. One differs with such a distinguished worker as Claparède with diffidence, but it is certain he was mistaken in supposing that the clitellum was not the entirely modified hypodermis.

(Schluß folgt.)

3. Pseudoscorpionidenkniffe.

Von Prof. C. Berg, Buenos-Aires.

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Die in diesem Blatte veröffentlichten Notizen von Wagner[1], Leydig[2] und Hickson[3], die Lebensweise der Pseudoscorpioniden betreffend, veranlassen mich zu einer Mittheilung, die vielleicht zur Klärung der darin behandelten Sache etwas beitragen dürfte. Ich befinde mich nämlich im Besitze einiger sehr interessanten Angaben,

[1] Dr. Franz Wagner, Biologische Notiz. Zool. Anz. XV. p. 434.

[2] F. Leydig, Zum Parasitismus der Pseudoscorpioniden. Zool. Anz. XVI. p. 36.

[3] Sydney J. Hickson, Note on the Parasitism of *Chelifers* on Beetles. Zool. Anz. XVI. p. 93.