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I. Wissenschaftliche Mittheilungen.

1. Notes on the Clitellum of the Earthworm.

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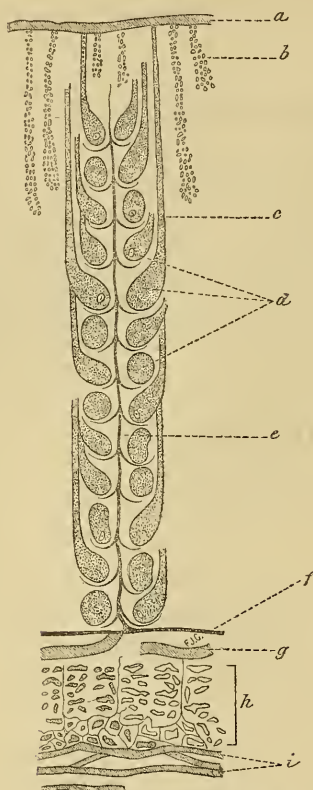
(Schluß.)

The calceo-cuticular glands (Fig. 2 *b*) are long straight, or wavy, tubes, running directly inwards, and in a clitellum which was $\cdot 55$ mm thick varied in length from $\cdot 1$ — $\cdot 15$ mm³. In another specimen $\cdot 6$ mm wide, they were $\cdot 15$ mm long, and I have found them (Zeiß, oc. microm. 3, obj. apochr., 40 mm., apert. 0.95) varying from $\cdot 0429$ to $\cdot 2245$ mm. With regard to the breadth, I have seen some measuring $3\cdot 3$ μ , others $6\cdot 6$ μ , and a few even $13\cdot 2$ μ . The amount of variation in length and breadth, therefore, is very large. The glands are densely granular and stain extremely readily — some of the granules having a diameter of $1\cdot 1$ μ . It is very easy, as I have just pointed out, to perceive the homology between the calceo-cuticular glands and the cells of the hypodermis, and to recognize that the former are simply

³ Claparède's measurements are as follows: [The second glandular layer I propose to call the calceo-cutaneous, from its position and the nature of its secretion. Hence the whole series may be known as the clitelline glands, which are of two kinds—viz., 1) the calceo-cuticular, and 2) the calceo-cutaneous. The measurements in italics are erroneous.] Calceo-cuticular, 4—5 μ wide; granules of same, 1 μ . Calceo-cutaneous (whole layer), 0.4—0.5 mm long, or three-fourths the width of the whole integument (excluding muscles); breadth of same, $\cdot 03$ — $\cdot 04$ mm. Nuclei, 4 μ long. (See Claparède's fig. As I have only observed these once, I have not figured them — thinking they might have wandered from the glands themselves.) Nuclei of calceo-cutaneous gland, 5 μ wide.

enlargements of the latter. Claparède says that » auch stoßen sie mit ihrem oberen Ende an die Hypodermis und es will mir scheinen, als ob sie mit diesen Wabenräumen direct zusammenhängen. Wir

Fig. 2.



L. herculeus, diagrammatic transverse section of clitellum. *a* Cuticle. *b* Calceo-cuticular glands. *c* Ducts of calceo-cutaneous glands. *d* Calceo-cutaneous glands and nuclei. *e* Supporting radial muscle fibre with lateral processes. *f* Circular muscle fibre, giving rise to radial fibres. *g* Portions of capillaries. *h* Longitudinal muscular layer in abnormal position. Note its two parts. *i* Circular muscular layer.

sahen bereits, daß die Wabenräume der Hypodermis sehr wahrscheinlich als eigenthümliche Drüsenkörper aufgefaßt werden müssen: in diesem Falle könnte man sich die Schläuche der Sattelsäulen als durch Einwachsen dieser Drüsenkörper bis in die Säulen hinein hervorgebracht vorstellen«.

From what has already preceded, and from the large number of sections which I have examined, I think there can be no doubt 1) that the calceo-cuticular glands are quite uniform throughout, and offer no grounds whatever for the belief that they are directly connected with anything else; 2) that there is no hypodermis, and therefore nothing else for them to be connected with. It seems also, both from his figure and text, that Claparède was likewise misled in supposing the calceo-cuticular glands to be simply the ducts of the *couche en piliers* — which my method of staining shows to be perfectly distinct.

With reference to the supposed cellular structure of the calceo-cuticular glands, and also of the cells of the hypodermis, I have not been able to detect even the »signs« of it that Claparède states he distinguished. It would be interesting to make it out, but at the same time there is, in my opinion, no histological evidence of its existence. I may mention that it is some-times difficult to get the calceo-cuticular glands well isolated on account of the external occurrence of large numbers of pigment granules.

Below the calceo-cuticular glands, and in part underlying them, there is a second series of glands, the *couche en piliers* as they are

described by Claparède, but which, as before stated, I shall call the calceo-cutaneous glands (Fig. 2*d*), reserving the word clitelline for both series.

The calceo-cutaneous glands are fairly large and very numerous, occupying, as Claparède says, about three-quarters of the integument (if the muscles be excepted). In a clitellum which was .55 mm thick these glands occupied from .45 to .4 mm of that space, and in another .6 mm thick, they again took up .45 mm. The individual glands measure from 13,2 to 16,5 μ across (thus being fairly constant), but vary in length from .0297 to .1326 mm. There are on the average about thirteen layers of these glands between the calceo-cuticular series and the muscular tracts.

The following quotations will now exhaust Claparède's observations on the subject of these notes: »Die Säulenschicht erreicht zur Zeit der Ausbildung des Sattels eine sehr bedeutende Dicke, nämlich bis 0,4 oder gar 0,5 mm, also circa $\frac{3}{4}$ der Gesamtdicke der Leibeswand. Sie besteht aus eng an einander liegenden, unregelmäßig prismatischen, zur Achse des Thieres radiär gerichteten Säulen. Jede Säule ist 0,03 bis 0,04 mm breit und ruht mit der Basis auf der Gefäßschicht, während sie mit dem entgegengesetzten Ende an die Hypodermis stößt. Sie besteht aus einer Rinde und einem Inhalt. Die Rinde wird durch ein homogenes Bindegewebe mit eingestreuten länglichen, circa 4 μ langen Kernen gebildet. In den pigmentierten Theilen des Clitellums liegen die Pigmentkörner in der äußeren Schicht der Rinde. Auf der Innenfläche der Rinde in das Innere der Säule vorspringend, kommen körnige Protoplasmahaufen mit je einem rundlichen, 5 μ breiten Kern versehen vor. Außerdem verlaufen in der Rinde Capillaren, die sowohl auf Quer- wie Längsschnitten zu erkennen sind. Diese Capillargefäße stammen von der Gefäßschicht ab und begeben sich bis an die untere Grenze der Hypodermis, wo sie, ohne sich zu verästeln, umbiegen, um nach der Gefäßschicht zurückzukehren. . . .

»Die unteren Säulenhälften enthalten einen beim ersten Blick homogen erscheinenden Inhalt. Eine genauere Untersuchung läßt jedoch erkennen, dass sie durch dünne Scheidewände in viele Räume zerfallen. Diese spärliche Kerne enthaltenden Scheidewände sind meist gewölbt mit nach unten gekehrter Convexität. Die Räume selbst sind mit einer bei den stärksten Vergrößerungen nur sehr fein granulös erscheinenden Substanz gefüllt. . . . Eine physiologische Deutung dieser Structur zu versuchen, wage ich bis jetzt nicht.«

Claparède is hardly accurate in his description of the position of the calceo-cutaneous glands, and it seems also that he did not get very satisfactory preparations. I have not seen anything that could

represent his free nuclei, although in one series of sections there were a few large nuclei with nucleoli lying between the layers of glands. I did not get the nuclei of the calceo-cutaneous glands at first, but made some preparations of them afterwards. Claparède's Rinde is of course the radiating muscular tissue I have represented in Fig. 2 e.

It is strange that Claparède does not figure any ducts to the calceo-cutaneous glands, as they are to a certain extent to be seen in all my sections. These ducts have at starting a diameter of about 6.6μ . They then taper down to 3.3μ , finally passing through the cuticle with a diameter of from 1.6 to 2.2μ . I had great difficulty in finding the openings of them. At first by a process of double staining, it was quite easy to trace them up to a certain point, even after they had begun to mingle with the calceo-cuticular glands. Then all signs of them vanished. I subsequently found, however, by other methods, that on approaching the surface they became granular and took the other stain, so resembling the ducts of the calceo-cuticular glands that it was all but impossible to distinguish between them (see Fig. 2). Although not shown in a single section, it is certain that each gland has a separate duct.

The capillaries are extremely difficult to find, and I think that great credit is due to Claparède for having worked them out. We have first of all a large vessel (which may be from 9.9 to 6.6μ thick) traversing the body in a circular direction on the external surface of that particular muscular layer which happens to be outermost. Then, as this goes along, it sends off radial capillaries, which, after reaching about the lower extremities of the calceo-cuticular glands, turn round, and, without anastomosing, go downwards to join the main vessel again—thus edging one glandular column. This condition of the capillaries is, I think, of a very interesting character, and affords a good illustration of the variety of form which is to be met with in the capillaries of the annelids.

I have not been able to get really satisfactory preparations of the peripheral nerves.

With reference to the origin of the clitellum, whether it secretes the cocoon, or whether, as I suppose, it has only a copulatory function, it is in any case necessary to consider why there should be two series of glands, and the work which each of them does. First of all, we can very readily imagine that in the primitive worm the epidermis consisted of simple nucleated cells, similar to the epithelial cells of the intestine. In fact D'Udekem (who first investigated the histology of the clitellum) actually compared the calceo-cutaneous glands with the

intestinal cells. If we admit the truth of any of the speculations⁴ regarding the ancestral history of the annelids, it is perfectly easy to see that with such a change of environment as they all require a strong cuticle would be an essential condition of existence. Hence the simple cells would become modified for secretory purposes, and the breaking up and distribution of the nucleus would doubtless accompany this change of function. Hence we arrive at the hypodermis stage. Now it of necessity follows that when the transition from either a coelenterate- or a planarian-like form to a terricolous annelid was being effected, the reproductive organs would become considerably modified. Certain it is that accessory copulatory apparatus would be necessary, and thus we have the origin of the clitellum. For this apparatus, in the process of evolution, would at first consist of thickened cuticle secreted by enlarged hypodermic cells, that is, by calceo-cuticular glands. Then, a strong connection of course being necessary, a further development took place — some calceo-cuticular glands being retained to provide cuticular matter, whilst others were differentiated for a purely calciferous function (the calceo-cutaneous glands), i. e. for providing a stout sheath by the deposition of carbonates in the cuticular substance. If the clitelline glands were to become functionless, then both the calceo-cuticular and the calceo-cutaneous layers would atrophy back to hypodermic cells, the former first.

Hence the presence of two series of glands is rendered intelligible, and by a hypothesis which the ontogeny of the clitellum entirely supports, or, I should rather say, suggests. A few verbal alterations will adapt it to any of the explanations of the function of this structure, which differ more in degree than in kind.

I wish, in conclusion, to express my indebtedness to Professor Burdon-Sanderson, F.R.S., who most kindly placed the resources of his laboratory at my disposal.

⁴ Lang, »Lehrbuch der vergleichenden Anatomie«, Jena, 1888, and »Der Bau von *Gunda segmentata*«, Mith. Zool. Stat. Neapel, III. 1882, believes the Chaetopods to have been derived from a leech-like type (according to Wilson — Journ. Morph. Vol. I. No. 1. p. 190, 1887 — this is supported by his observations on the development of the germ-bands of *Lumbricus*), which in turn took its origin from a Polyclade Turbellarian, and this again from a Ctenophore—hence indirectly connecting the Annelids with the Coelenterates. Balfour (»Comparative Embryology«) and Sedgwick (»Origin of Metameric Segmentation«, Quart. Journ. Microsc. Sc. XXIV. 1884) believe in coupling the annelids directly with the Coelenterates (the latter with the Actinozoa), and Wilson (Journ. Morph. Vol. III. No. 3. p. 441. 1889) states that the results of his researches on the trochosphere and the teloblasts of the earthworm might be interpreted either way. Of course, as far as we are concerned, these hypotheses may be considered as identical.

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