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I.—*On the Rectal Papillæ of the Fly.*

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THE organs for which I have retained the name given to them by Weismann, are four in number, situated near the termination of the alimentary canal. They are hollow, conical, glandular organs, about $\frac{1}{30}$ th of an inch in length, enclosed in a dilatation of the rectum, and having their bases only external to its cavity. I think I shall be able to show that their function is the excretion of a urinary fluid; I have, however, retained an anatomical name, instead of giving them a physiological one, because its applicability is obvious, and admits of no difference of opinion; it is not a new name; and, lastly, had I called them kidneys, or even renal organs, I should have been comparing them to the totally dissimilar structures found in vertebrates.

Each papilla consists of three parts: an internal central cavity, surrounded by a transparent structureless membrane; around this a hollow cone of gland cells, the secreting portion of the organ, is disposed; and external to this again, a tough transparent cone of membrane, which I shall call the calyx of the papilla, perforated by numerous minute pores, surrounds the whole of that portion of the organ which is internal to the rectum. By a little dexterous manipulation these parts may be separated completely from each other

DESCRIPTION OF PLATE XVIII.

- FIG. 1.—The rectum with its papillæ.
" 2.—Base of a papilla, showing the muscular layer $\times 75$ diam.
" 3.—A flattened muscular band from the same $\times 250$ diam.
" 4.—Calyx of the papilla $\times 75$ diam.
" 5.—Central cavity and portion of the gland structure $\times 75$ diam.
" 6.—Apex of the calyx $\times 250$ diam.
" 7.—Base of a papilla, the muscular layer removed, showing the arrangement of the tracheæ.
" 8.—Transverse section through the middle of a papilla $\times 75$ diam.
" 9.—Crystals of uric acid from the urinary secretion of the fly.

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(Plate XVIII., Figs. 4, 5); or, by hardening the papillæ in chromic acid, sections may be made showing the relations of the parts *in situ*. Fig. 8 represents such a section.

The calyx (Fig. 4) is perforated by about 300 minute pores, each pore being surrounded by a nipple-like projection, which is surmounted by from three to eight minute setæ (Fig. 6). The whole membrane of the calyx becomes thickened towards the apex, where it has a faint, yellow tint; it is near the apex that the nipple-like projections and their setæ are best seen, indeed a casual observer might overlook their presence entirely at the upper portion of the calyx.

The calyx itself is marked by faint reticulations, and its margin is deeply crenated. These are the only indications of structure which it presents, and these seem to point to its being a fibrous membrane, especially as two sets of muscular fibres arise from the crenations of its margin.

These muscular fibres are, first, a set from the muscular coat of the rectum, and, secondly, a layer of converging fibres which cover the whole base of the papilla to within a very short distance of its centre, and which apparently end in the edge of the membrane forming the boundary of the central cavity, although from the extreme transparency of this membrane it is nearly impossible to be certain of their insertion (Fig. 2).

Each papilla is supplied with air by a large tracheal vessel from the last abdominal spiracle, which divides into several—generally five or six—large trunks before entering the papilla. The tracheæ of the papilla may be divided into two sets as soon as they enter the base of the organ; first, from twenty to thirty radiating lateral branches which run to the edge of the base (Fig. 7), and then pass over the outer surface of the glandular structure to the apex of the cone, giving off numerous branches, which anastomose freely, and form a fine reticulation around the gland cells, the larger branches running directly towards the central cavity, and forming loops by anastomosing with other similar vessels (Fig. 8).

The second set are the terminations of the main tracheæ: after giving off the lateral branches these run directly into the central cavity, where they become tortuous, and anastomose with each other, giving off comparatively few small vessels in proportion to their size, and forming a network which fills the central cavity, but none of their branches pierce its investing membrane anywhere. Fig. 5 represents the central cavity with its tracheæ, with a small portion of the lateral branches and their terminations amongst the glandular structure.

Each papilla receives two or three nerve filaments from one of a pair of nerves given off at the termination of the ventral cord, which are distributed to the muscular coat of the rectum; a few

very small filaments appear to accompany the tracheæ into the central cavity.

The gland cells are large—about $\frac{1}{300}$ th of an inch in diameter—and slightly angular by mutual pressure; each contains a granular nucleus about one-third the diameter of the cell.

In order to understand the functions of these organs it will be necessary to investigate briefly the structure of that portion of the alimentary canal which encloses them. About two lines above the anal orifice a sphincter, or rather a kind of muscular valve, closes the intestine (Fig. 1, *a*). A little below this the rectum becomes much dilated, and its muscular coat correspondingly attenuated; when the insect first emerges from the pupa case this dilatation is filled with a semi-solid mass of uric acid. I have never found any of this substance above the valve I have just described—an important fact in relation to the function of the rectal papillæ.

There is nothing new in the fact that insects excrete uric acid; figures of crystals of this substance from the excrement of the clothes-moth and stag-beetle will be found in the 'Micrographic Dictionary.' I have given figures of several forms from that of the fly (Fig. 9); the only question is by what structure is this substance eliminated.

There are only two gland structures which open into the alimentary canal of the fly—the rectal papillæ and the malpighian or liver-tubes; these latter, beside opening into the intestines more than two lines above the valve I have described, contain cells which from their contents—oil-globules and yellow pigment—are unmistakably liver-cells. I have compared these carefully with cells from the liver of the bullock, and could see no difference except that those of the latter animal contained more and larger oil-globules than are present in the liver-cells of the fly. Hence I conclude that we must not look to the malpighian tubes for the origin of the urinary secretion.

On the other hand, the structure of the rectal papillæ is just such as we might expect to find in a renal organ. If I am right in my belief that the central cavity is continuous with the visceral cavity, it affords a mean of bringing the circulating fluid into almost immediate contact with the secreting cells, a fine structureless membrane only, being interposed—still further I believe I am justified in asserting that the circulating fluid is expelled from, and a fresh supply is drawn into, the central cavity by a rhythmic muscular act.

In the female fly the rectal papillæ lie fortunately between the second and third rings of the ovipositor when that organ is exerted, where it is sufficiently transparent to allow of the papillæ being seen during life. I have repeatedly observed a movement of the kind I have described. I believe this is the explanation of the

radiating bands of muscle at the base of the papillæ ; they probably open the central cavity, and at the same time press upon the contents of the papillæ, and, assisted by the muscular wall of the rectum, which contracts at the same instant, they not only expel the contents of the central cavity, but also press the secreted fluid through the minute pores in the calyx into the cavity of the rectum ; the central cavity is probably refilled by the elasticity of the calyx itself.

There is no trace of these organs in the maggot, and at present I cannot state at what precise period they first appear in the pupa, but as soon as the embryo fly, if I may be allowed the expression, has become so far developed that its principal parts may be easily recognized, about the end of the second or the beginning of the third week of the pupa state, the calices of these organs are already formed and filled with gland-cells, larger than those in the adult fly, but otherwise similar ; the tracheal vessels are quite rudimentary and very transparent, and the calices themselves are striated coarsely, but exhibit the nipple-like pores so characteristic of them. No muscular fibres are then distinctly traceable, but their position is marked by the presence of rapidly growing cells.

With regard to the urinary secretion itself, that passed by the insect when it first emerges from the pupa case is a semi-solid mass of nearly pure uric acid ; that passed afterwards is a turbid fluid, sometimes almost clear, and very irritating when applied to any tender part of the skin : this fluid deposits an abundance of crystals of uric acid when acidulated with hydrochloric or nitric acids. Fig. 9 represents the principal forms of these crystals. I believe the acid is held in solution by ammonia, but of this I am not certain. The excrement of the fly when heated over a lamp gives off a strong urinary smell.