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Investigation of the Phenomena of Digestion in Insects. By M. FÉLIX PLATEAU. (An abstract of his paper in the 'Mémoires de l'Acad. Roy. de Belgique,' tome xli. 1874. Communicated by the author.)

The necessity of having recourse to animals possessing an organization resembling our own for the purpose of solving the various problems of human physiology has led to the carrying out of a multitude of experimental researches, the results of which when brought together and discussed constitute the comparative physiology of the Vertebrata, which, however, still exhibits important gaps arising from the preponderance that has been given to the study of certain classes to the neglect of the rest. The division which has received most attention next to the Vertebrata is that of the Arthropoda. We already possess valuable treatises on the locomotion, the innervation, the circulation, the animal heat, the secretory phenomena, and especially the embryonic development of these animals; but it will be remarked that digestion has been left almost entirely in the shade.

Attracted by the novelty of the subject, but without losing sight of the difficulty of the task, we have endeavoured to fill up this gap by repeating on a small scale what so many others have done on a large scale for the Mammalia—by feeding Articulate animals, following, often step by step, the modifications of their food in the digestive tube, analyzing as far as possible the liquids secreted by the walls and glandular appendages of the latter, attempting artificial digestions, &c.*

Although our investigations have for several years embraced the whole of the group, we have thought it better at present to publish only what relates to the Insects†; and we do this with the confidence derived from work performed with minute care, but also with the conviction that we have done no more than to place a landmark as the starting-point for future studies.

Our observations, and especially our experiments, have led us to results some of which are in complete disagreement with what we find stated in recent classical treatises. Could it well be otherwise? The authors of the works of which I speak had before them as materials nothing but almost exclusively anatomical data, of which they have taken the best advantage in their power by depending upon analogies of form.

To be as brief as possible, I shall confine myself to an abstract of the summary which concludes my memoir.

When the *salivary glands* are not diverted from their original function to become silk-glands, poison-glands, &c., they secrete a neutral or alkaline liquid, possessing, at least in the case of one of

* Respect for priority makes it our duty to point out to the reader that the first experiments in artificial digestion by means of the digestive liquids of an Arthropod were made by M. Emile Blanchard in his researches on the Scorpion ('Organisation du Règne Animal,' Arachnides, p. 66).

† The description of the phenomena of digestion in the Myriopoda, the Crustacea, and the Arachnida will appear hereafter.

the pairs of glands, the characteristic property of the saliva of the Vertebrata, of rapidly converting feculent aliments into soluble and assimilable glucose.

In a great many cases (carnivorous insects, Orthoptera, &c.) the œsophagus is dilated into a *crop* terminated by a narrow valvular apparatus. The food, more or less divided by the organs of the mouth, accumulates in this crop, which is very dilatable, is there impregnated by peculiar neutral or alkaline liquids, and undergoes an evident digestive action, the result of which, in carnivorous insects, is the transformation of the albuminoid materials into soluble and assimilable substances analogous to the peptones, and, in insects which feed upon vegetable substances, an abundant production of sugar at the expense of starch. This digestion in the crop is very slow; and until it is terminated the following part of the alimentary tube remains empty.

When the digestion in the crop has come to an end, the materials, subjected to a strong pressure on the part of the walls of the organ, glide or filter, by degrees, through the *valvular apparatus* (gizzard of authors), being directed in their course by the furrows and chitinous projections of the latter. The vascular apparatus is not a tritulatory organ auxiliary to the buccal organs; for in the carnivorous beetles and in the Locustina, in which it affects a classical form, the animal or vegetable matters which have traversed it are found after the passage in portions of the same size and form as before the operation.

In the insects which have neither a crop nor a valvular apparatus, the food passes continuously into the middle intestine.

In the *middle intestine* (chylic stomach of authors) the alimentary materials which have resisted the action of the crop, or those which have penetrated into it directly in the insects which do not possess the crop and the valvular apparatus, are submitted to the action of an alkaline or neutral, but never *acid* liquid, secreted either by special local glands, as in the Orthoptera, or by a multitude of small glandular cæca, as in many Coleoptera, or by a simple epithelial lining. This has no analogy with the gastric juice of Vertebrates; its function is different according to the group to which the insect belongs: in the carnivorous Coleoptera it is an active emulgent of fatty matters; in the Hydrophilian Coleoptera it continues the transformation of starch into glucose which commenced in the œsophagus; in the Scarabæida it also gives rise to glucose, but this action is local, taking place in the middle intestine and nowhere else; in the caterpillars of Lepidoptera it determines a production of glucose and at the same time acts as an emulgent of fatty matters; lastly, in the herbivorous Orthoptera there seems to be no further formation of sugar in the middle intestine, but this body is produced and absorbed entirely before passing the crop.

The middle intestine is generally evacuated slowly and continuously into the *terminal intestine*, the first portion of which, usually long and slender, is very probably the seat of an active absorption. The epithelial lining of the walls in some species seems, however, to

indicate that secondary digestive phenomena may take place in it. The reaction of the contents is neutral or alkaline.

The second, wider portion of the terminal intestine only performs the function of a stercoral reservoir. It is associated, for example in the Dytiscidæ, the *Nepæ*, and the *Ranatra*, with a voluminous cæcum, which is not a natatory bladder as has been supposed. It may be empty or full of liquid, but never contains any gas. The liquid product secreted by the Malpighian tubes accumulates there, and, under certain circumstances, deposits in it calculi which may be of considerable size.

Some substances resist the digestive action and are passed with the excrements. Such are the chitine of the integuments of insects, vegetable cellulose, and chlorophyl; the microspectroscope enables us to detect the last at all parts of the alimentary tube of herbivorous insects.

Insects have nothing resembling the chyloferous ducts. The products of digestion, dissolved salts, peptones, sugar in solution, and fatty emulsions, traverse the comparatively thin coats of the digestive tube by a phenomenon of osmosis, and mix with the blood outside this tube.

The Malpighian tubes are exclusively depuratory and urinary organs, which free the body from the products of the wear of organic elements. The liquid that they secrete contains urea (doubtful), uric acid, urates in abundance, hippuric acid (doubtful), chloride of sodium, phosphates, carbonate of lime, oxalate of lime in quantity, leucine, and colouring-matters.

As to the so-called *anal glands*, the product they secrete is very variable in different groups; but it has no part to play in digestion, and is not urinary.

On the Structure and the Development of the Sting and Ovipositor of some Hymenoptera and of Locusta viridissima. By Dr. H. DEWITZ.

It has generally been admitted, until within the last few years, that the parts which are found at the posterior extremity of the bodies of insects, and which constitute nippers, cerci, the ovipositor, and the sting, are formed by the transformation of certain segments, or at least of some arches of segments. However, new views as to the origin and signification of these organs were introduced into science in 1866 by Packard and Weissmann. Memoirs directly or indirectly relating to this subject have been published more recently by Ganin in 1869, and lastly by Oulianin and Kräpelin in 1872 and 1873.

The embryological researches of M. Dewitz, which relate to *Locusta viridissima*, *Apis mellifica*, *Bombus* sp., *Vespa vulgaris*, and *Cryptus migrator*, have led him to the discovery of some important facts, which confirm, in a general way, the opinion of the anatomists whom we have just mentioned, completing and rectifying certain points of their observations. To give an idea of the results