

Note on the Cœlom and Vascular System of Mollusca and Arthropoda.

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THE reference by Mr. Allen in his memoir published in this number of the Journal to a note by me appended to Dr. Gulland's paper in 1885 on "The Coxal Gland of *Limulus*" induces me to reprint here the report of a paper which I read to Section D at the Manchester meeting of the British Association in 1887. This report was furnished by me to 'Nature,' and printed in that journal in March, 1888 (p. 498). Professor Julin, of Liège, also published—in a report made by him to the Belgian Academy on the proceedings at Manchester—an abstract of the same paper. The report printed in 'Nature' is as follows :

"The object of the author was to establish the fact that the system of blood-containing spaces pervading the body in Mollusca and in Arthropoda was not, as sometimes (and indeed usually) supposed, equivalent to the cœlom or perivisceral space of such animals as the Chætopoda and the Vertebrata, but was in reality a distended and irregularly swollen vascular system—the equivalent of the blood-vascular system of Chætopoda and Vertebrata. Hence he proposed to call the body-spaces of Mollusca and Arthropoda 'hæmocœl,' in contradistinction to 'cœlom.' It had been held by previous investigators that in Mollusca and Arthropoda the cœlom and the vascular system were united into one set of spaces—whether by a process of gradual fusion, or owing to the fact that the two systems had never been differentiated from a common

original space representing them both in the ancestors of these two great phyla. The author stated that he had been led to the view which he now formulated by his discovery of distinct spaces in both Mollusca and Arthropoda, which appear to be the true cœlom, and are separate from the swollen vascular system.

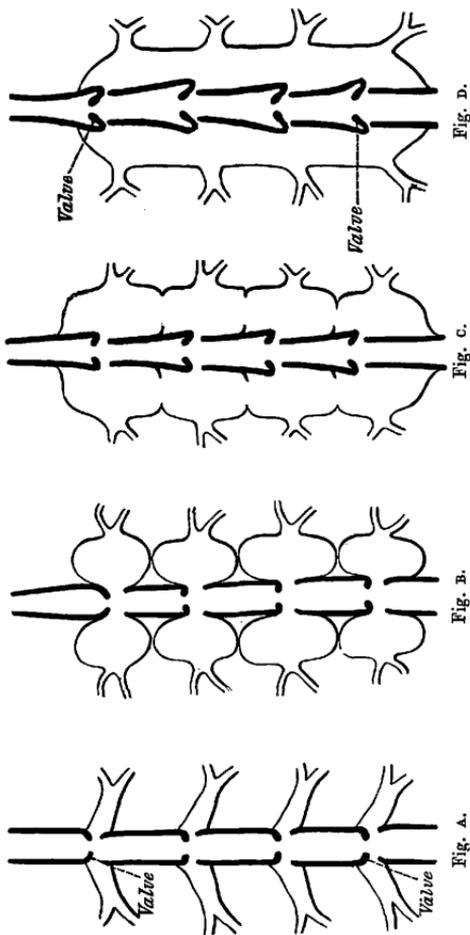
“ In Mollusca the pericardial space is the chief representative of cœlom. It is usually taught that the pericardium of Molluscs contains blood, and is in free communication with veins; but the author had succeeded in showing by observations on the red-blooded *Solen legumen* (already published, ‘*Zoolog. Anzeiger*,’ No. 170, 1884), and by more recent careful investigation of *Anodonta cygnea*, *Patella vulgata*, and *Helix aspersa*, that the pericardium has no communication with the vascular system, and does not contain blood. The perigonadial spaces (so-called generative glands) and the pericardial space (which has arborescent tubular out-growths in some Lamellibranchs forming Keber’s organ) are, then, the cœlom of the Mollusca. It is quite distinct from the hæmocœl. In Cephalopods, and in the archaic Gastropod *Neomenia*, the pericardial and perigonadial cœlomic remnants are continuous, and form one cavity. There is strong reason to believe that in ancestral Molluscs the hæmocœl was more completely tubular and truly vasiform than it is in living Molluscs. In the later Molluscs the walls of the vessels have swollen out in many regions (especially the veins), and have obliterated the cœlom, which has shrunk to the small dimensions of pericardium and perigonadium. There are, however, many Molluscs with complete capillaries, arteries, and veins, in certain regions of the body. These had been recently studied by the author by means of injections, and by silver impregnation, and drawings illustrative of them were exhibited to the Section.

“ With regard to the Arthropoda, Professor Lankester formulated the same view, viz. that the ancestral blood-vessels have swollen and enlarged, especially the veins, so as to form large irregular spaces, which have blocked up and so obliterated the

previously existing cœlom. Nevertheless the cœlom still persists in some parts of the Arthropod body quite separate from the swollen blood-vascular system. It persists as the tubular generative glands (perigonadium), and also as a system of small spaces (lymph-system) in the connective tissue of *Astacus* and of *Limulus*, and as the internal terminal vesicle of the green glands and other nephridia present in various Arthropoda. Professor Lankester stated that he had been led to this view with regard to the vascular system and cœlom of the Arthropoda by the results of his histological investigations on the vascular system and connective tissues of *Astacus* and *Limulus*, and by the results obtained in his laboratory by Mr. Gulland in studying the development of the nephridial 'coxal gland' of *Limulus* (already published, with note by Professor Lankester, in the 'Quart. Journ. Micr. Sci.,' 1885, vol. xxv, p. 515). He had also been led to this view by the attempt to explain theoretically the origin of the peculiar structure of the Arthropod's heart and blood-holding pericardium.

"The Arthropod's heart and pericardium are absolutely peculiar to the group, and characteristic of all its members, even of *Peripatus*. The author had asked himself how the existence of a tubular heart with paired valvular apertures in each segment of the body, lying within a blood-holding sac, could be explained. He conceived that it might best be explained by that tendency of the veins to dilate and to form irregular large blood-sinuses, which on other grounds we have reason to consider as a structural tendency of Arthropods. Each pair of valvular apertures in the Arthropod's heart represents a pair of distinct tubular veins, which in the ancestors of the Arthropoda brought blood to the heart from the gills. These veins have dilated, and their adjacent walls have been absorbed, so that we now have, instead of a series of veins, a great continuous blood-sinus on each side of the heart or dorsal vessel.

"Capillaries of the finest dimensions were shown by Professor Lankester to exist in certain parts of *Astacus* and of *Limulus*. In studying these he had come across the remnants of cœlom.



DIAGRAMS ILLUSTRATING PROFESSOR LANKESTER'S THEORY OF THE DEVELOPMENT OF THE ARTHROPOD HEART AND PERICARDIAL SINUS.

Fig. a.—Dorsal vessel and veins with valves at their junction with the dorsal vessel. Chætopod stage.

Fig. b.—Hypothetical. The veins dilated.

Fig. c.—Hypothetical. The veins further dilated and now made confluent by the absorption of their adjacent walls.

Fig. d.—Arthropod heart with four pairs of ostia and a pericardial blood-sinus.

Between the capillaries and unconnected with them—in the connective tissue of both *Astacus* and *Limulus*—is a system of spaces containing a coagulable fluid. (These spaces were described and figured in *Limulus* in 1884 by Professor Lankester in the 'Quart. Journ. Micr. Sci.'). It is into this system of spaces that the tubular nephridium which becomes the coxal gland of *Limulus* opens. Hence these spaces are remnants of the cœlom, elsewhere blocked up and obliterated by the swollen veins which form the hæmocœl. The tubular generative glands of Arthropods are to be explained as perigonadial cœlom communicating with the exterior through modified nephridia. Beddard's discovery of such a condition of the ovary and oviduct in the earthworm *Eudrilus* is confirmatory of this explanation.

"The views which had been thus arrived at by Professor Lankester, and very briefly indicated in the note in the 'Quart. Journ. Micr. Sci.,' 1885, p. 515, have received a startling and demonstrative confirmation in Sedgwick's brilliant results as to the development of cœlom and hæmocœl in *Peripatus*, published in the 'Quart. Journ. Micr. Sci.,' February, 1888, and announced early in 1887 to the Cambridge Philosophical Society."

To this brief statement I may now add that it has been for some time my desire to obtain well-preserved specimens of *Lernanthropus*, the remarkable Copepod with a tubular vascular system containing hæmoglobinised blood, first described as possessing this peculiarity by Edouard van Beneden, and subsequently figured and described in detail by Heider ('Arbeiten Zool. Inst. Wien,' Bd. ii, 1879). It would be extremely important to ascertain, if possible, whether the tubular vascular system of *Lernanthropus* co-exists with spaces which can be identified with the supposed hæmocœl of other Crustacea, or whether, as should be the case if my theory is correct, the spaces in *Lernanthropus*, which are not in continuity with the red vascular system, can be identified as "cœlom," and distinguished from "hæmocœl spaces."

I have failed to obtain *Lernanthropus* either from Plymouth

or from Naples. If any naturalist reading these lines should be able and willing to furnish me with specimens he would confer a great favour on me by communicating with me.

The question in regard to *Lernanthropus* may be further stated in this way: is the tubular vascular system of that animal an heirloom from Annelid-like ancestors with the characteristic Chætopod's vascular system? or is it a special development *de novo* peculiar to this Copepod?

One of the most attractive features about the theory of dilated veins in the Arthropods is the simple explanation which it affords of an otherwise puzzling structure, namely, the Arthropod heart. I therefore venture to present here a diagram which I have made use of during the last six years in my lectures illustrating the possible—I think we may say the probable—steps by which the Arthropod heart, with its curious valvate ostia and blood-holding pericardial space, was developed from the dorsal vessel of a closed "tubular" vascular system such as that of the earthworm.