Dr. Derham also supplies what has long been wanted, a scientific hydrometer having a succession of poises to continue the series the indications of which are also specific gravities. It is well known that, in order to effect this, the increment to the total bulk of the instrument with each successive poise should be the bulk of the graduated stem. Bates's saccharometer is a more or less successful mechanical adaptation of this requirement. But it had escaped previous inventors that, in order to perfectly satisfy the conditions of the problem, the specific gravities of the successive poises should bear an exactly defined relation to the specific gravities to be indicated by the instrument. The principle upon which the calculation of the hydrometer is based is that—

$$\frac{\text{weight}}{\text{bulk}} = \text{specific gravity.}$$

Let W = weight of hydrometer; B = bulk of hydrometer; G = initial specific gravity of the instrument; g = specific gravity of any poise; a = the number of degrees of gravity indicated in the length of the stem; and unity = bulk of graduated stem; then, since the bulks of the poises must be multiples of the bulk of the graduated stem, according to their position in the series,

n = bulk of nth poise.
ng = weight of ,,

By the definition of specific gravity,

$$\frac{W}{B} = G; \text{ and } \frac{W}{B - 1} = G + a,$$

whence

$$W = BG, \text{ and } \frac{BG}{B - 1} = G + a,$$

and

$$Ba = G + a.$$

Again, generally, with nth poise attached,

$$\frac{BG + ng}{B + n} = G + na,$$

whence

$$g = 2G + (n + 1)a.$$

And if the hydrometer were intended to indicate gravities from ·780 to 1·000, the value of the stem being ·020, and the initial specific gravity accordingly of each range ·800, ·820, ·840, &c., the successive specific gravities of the poises would be 1·60, 1·62, 1·64, &c.

THE CŒLOM AND THE VASCULAR SYSTEM OF MOLLUSCA AND ARTHROPODA.[1]

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 Mollusks 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 outgrowths 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 Mollusks the hæmocœl was more completely tubular and truly vasiform than it is in living Mollusks. In the later Mollusks 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 Mollusks 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, Prof. 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. Prof. 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 Prof. 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 Prof. Lankester to exist in certain parts of Astacus and of Limulus. In studying these he had come across the remnants of cœlom. 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 Prof. 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 Prof. 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.

[1] Abstract of a Paper read in Section D, at the Manchester meeting of the British Association, by Prof. Ray Lankester, F.R.S.