oxygen lines, which only appeared at very high temperatures. The capillary portion of the tubes we used was much shorter than that in the ordinary Plücker's tubes, and this accounts for the temperature of the incandescence being higher than usual. As one of the lines is near the unknown aurora line, its wave-length was determined and found to be 5591, showing it to be decidedly less refrangible than the aurora line.

The experiment was repeated in four different tubes and many times in each tube; but whether graphite or diamond was employed, no line was seen which was not also obtained in a tube of the same dimensions containing carbonic oxide.

XI. *On the Anal Respiration of the* Copepoda.

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Read December 16, 1879.

In a note on *Cyclops* read at the British Association I pointed out that its respiration was exclusively anal. I have now made out the same in *Canthocamptus* (fam. Harpacticidæ) and *Diaptomus* (fam. Calanidæ). In all three the mechanism is the same; at regular intervals, after the backward sway of the intestine, the anal valves open for an instant and then close, giving just time for a slight indraught of water after the opening, a slight expulsion at the close. The necessary pressure to confine the animal seems to interfere somewhat with these move-

ments, sometimes stopping them if excessive; hence I refrain from noting with illusory exactness the intervals between each respiratory movement.

It is to be noticed that the rectum contains, as a rule, liquid only, the bolus of fæces remaining in it but a short time. By endosmose the liquid in the rectum will tend to be at the same condition of gaseous saturation as the body fluid around it, kept constantly agitated by the backward-and-forward sway of the stomach. During the short interval that the anus is open an approach to gaseous equilibrium with the external water takes place, even despite the very slight movement of the water (shown by the little change of place undergone by suspended indigo or carmine particles). In the absence of any other suitable respiratory apparatus, no one can hesitate as to the function of the action I have described.

In the *Nauplius* larvæ of *Cyclops* and *Diaptomus* the working is slightly different. The rectum is a sub-spherical muscular sac, which at regular intervals contracts so as to leave a linear cavity (along the long axis of the animal), and immediately dilates, sucking up the water from without.

An anal respiration, such as that of *Cyclops*, is found widely among Crustacea—even those which have well-developed gills like *Astacus*, which is one of the highest forms. It has been demonstrated in Phyllopoda and Cladocera, and is here probably the exclusive mode in *Leptodora*, as shown by Weismann. That it is therefore primitive, and should be expected to occur in the primitive or at least very generalized group of the Copepoda, is an obvious deduction. Hence I anticipate that the homœomorphic *Zoea* larvæ of the Decapoda will prove to have this same mode of respiration.

If there be any connexion between Rotifers and *Nau-*

plius, it is easy to make out the origin of the arrangement in the latter. The ciliated funnels and lateral canals of the former can only be of service when there is a thin unchitinized anterior surface through which water can transude into the cœlom: by the extension of chitinization over the whole surface these organs lose their function and abort, while the cloacal "contractile vesicle" takes on an inspiratory as well as an expiratory function, and becomes more or less confounded with the rectum, from which probably, even in Rotifers, it takes origin.

Here must be noticed the wide diffusion of anal respiration in aquatic insect larvæ (alternate inspiration and expiration by the pumping movements of the rectum). This would point to a common origin with Crustacea.

A list of the groups in which anal respiration is made out may be added.

VERMES:

Rotifera.
Gephyrea.
Oligochæta Limicola.

ECHINODERMATA:

Holothuroidea.

ARTHROPODA:

Crustacea (general).
Insecta (most aquatic larvæ).