XIX.—Notes on Food-Capture and Ciliation in the Ephyræ of *Aurelia*.

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(*With Text-figures.*)

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1. Food-Capture.

If we examine a healthy young ephyra of *Aurelia* in clean sea-water under suitable magnification, we shall probably find the gastric cavity empty or nearly so. Turn the ephyra mouth-upwards and leave just enough water in the dish to allow it to pulsate without righting itself. Now introduce some drops of a culture rich in marine ciliates of good size, and allow mixing. In many cases you will hardly have time to get the ephyra under observation again before some of the ciliates have been taken into the gastric cavity. The number increases with surprising rapidity. As a rule the ingested ciliates are dead and disintegrating, but some species remain active after ingestion for a period which is longer or shorter according to the freshness and vigour of the ephyra. It is interesting to note how the ciliates are captured. The two lappets at the end of each ephyra arm are furnished, especially along their sides, with highly sensitive stinging cells capable of quickly extruding their long cnidotrichs. An infusorian touching a lappet is pierced and held by the stinging threads. Its movements usually get hampered by mucus or other colloid material produced, no doubt, chiefly by the lappet cells, but probably added to by the action of the poison on the prey. All the arms stop beating, or, more rarely, only the arm concerned ceases to beat. This arm now bends towards the manubrium and the manubrium bends towards the arm, while the lips stretch open widely in the same direction. The lappet is next slowly wiped across the lip and the infusorian thus detached. The latter now travels slowly down the manubrial canal to the stomach. I think it is carried by a central inhalant current which is compensatory to exhalant currents produced by ciliary action in the floor of the mouth angle grooves, but this may not be the whole explanation. It is curious to note how cleverly that part of the lappet which carries the infusorian is brought over the mouth. Thus if the prey is attached to the aboral surface, the arm and lappet curl completely round: if to the lateral surface, they are flexed in the necessary degree. Even the lips show fine adaptiveness, stretching and adjusting themselves to difficult captures. Their efforts, though persevering, are often fruitless, but they suggest appetite and desire as definitely as do the facial movements of ingenuous esurient higher

animals in the presence of food. Any arm may bring its contribution at any time, and the mouth seems sometimes puzzled which to attend to first. An ephyra swimming in a tank is occasionally seen to stop and flex one or more of its arms towards the mouth. It may be feeding in the manner just described, but in any case every pulsation is capable of wiping one or more of the lappets against the mouth.

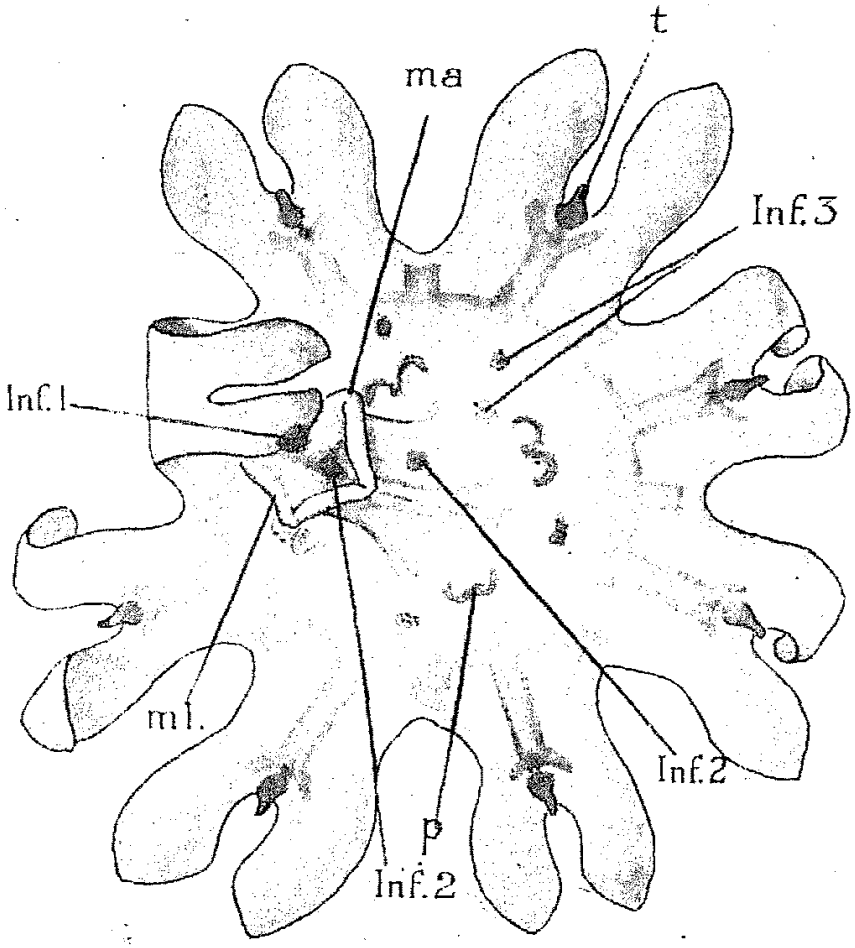

FIGURE 1.

To illustrate capture of infusoria by ephyræ ; see explanation in text.

Inf. 1. Infusorian paralysed and adherent to lappet but in course of being transferred to mouth.
Inf. 2. Infusorian within manubrial canal.
Inf. 3. Infusorian within gastric cavity.

m.a.—mouth angle ; *m.l.*—lip ; *p.*—gastric filaments ; *t.*—tentaculocyst.

Infusoria struck by the stinging threads are sometimes killed at once and begin to disintegrate before they are swallowed. Sometimes they are merely paralysed, and, resuming activity after a short time, manage to escape. Nauplius larvæ and minute Copepods may be attacked by young ephyræ with occasional success. However, out of over 2000 ephyræ 1 to 5 days' old from the Millport tanks, which I examined for abnormalities, not one showed

recognisable crustacean remains in the gastric cavity. On the other hand, I watched ephyræ in captivity capturing and swallowing infusoria for at least the first two weeks of their life.

The note on ciliation which follows will show that infusoria with other particles always tend to be swept towards the chief cnidoblast fire-zone (*i.e.* the lappets), from the whole exumbrellar surface, and from the subumbrellar surfaces of the arms and outer part of disc. The currents over the rest of the subumbrellar surface direct the prey to the lips, and observation shows that killing and paralysing can, though less readily, be done by the cnidoblasts of this surface. It is interesting to note that the scyphistoma captures infusoria in much the same way as the ephyra, the tentacles taking the place of the arm lappets, and twitching more quickly towards the mouth when the prey comes against them.

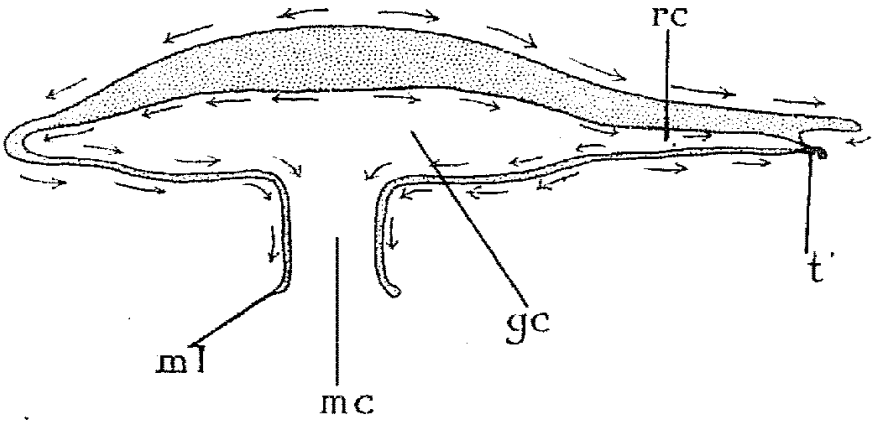

FIGURE 2.

Diagrammatic vertical section of an *Aurelia* ephyra passing through an arm on one side and an interspace on the other. See description in text.

g.c.—gastric cavity; *m.c.*—manubrial canal; *r.c.*—radiating canal; *t.*—tentaculocyst.

2. CILIATION.

It goes without saying that ciliary activity, though unobtrusive, is highly important for many marine animals, and deserves careful study by the morphologist as being a function to which the forms of particular animals or of their parts are closely related and in many cases subservient. Text-fig. 2 shows the general scheme of the ciliation in a young ephyra of *Aurelia*. The scheme may be summarised as follows:—

1. *Exumbrellar surface of disc, arms, and lappets*—currents centrifugally outwards. Many ephyræ show a torsion of these currents clockwise as seen from the aboral side, corresponding with the counter clockwise rotation which accompanies progression in the free swimming planula stage. Even 12-tentacled scyphistomas if

detached will move slowly aboralwards by ciliary action, and rotate counter clockwise as viewed from the aboral end.

2. *Subumbrellar surface of arms*—centrifugally outwards.
   Subumbrellar surface of disc—centrifugally outwards on a marginal zone of about a quarter radius breadth; centripetally on remainder.
   Subumbrellar surface of manubrium—towards the mouth opening.
3. *Internal surfaces.*—Roof of gastric cavity and of all radiating canals—centrifugally outwards.
   Floor of gastric cavity and of all radiating canals—centripetally inwards.
   Manubrial canal—ciliation absent or ill-defined, except in floor of radial grooves where it is weakly exhalant.
   Gastric filaments—from base to tip of each filament.

The usefulness of the ciliation throughout the internal cavities is obvious. That of the external ciliation in relation to feeding is referred to on p. 224.

Widmark has described the ciliation in the *Aurelia* itself. Among characteristics he notes that there is well-marked centripetal movement of fluids along both the perradial and interradial canals, and centrifugal movement along all the adradials, while the perradial grooves of the manubrial cavity exhibit strong ciliary action towards the mouth opening.

The medusa of *Melicertidium* exhibits much the same internal ciliary activities as the *Aurelia* ephyra, but externally ciliation is absent from the exumbrellar and considerable portions of the subumbrellar surfaces.

References to recent papers on ciliation in other marine invertebrates are given below.

1. Carlgren, O. *Biol. Centralbl.*, xxv., 1905, pp. 308-322 (Actinians, Madreporarians).
2. Orton, J. H. *Journ. Mar. Biol. Ass. U.K.*, ix., 1912, pp. 144-178 (Ascidians, Molluscs): *ibid.*, x., 1913, pp. 19-49 (Amphioxus, Ascidians, Molluscs).
3. Widmark, E. M. P. *Zs. Allg. Phys. Jena*, xv., 1913, pp. 33-48 (Aurelia).
4. Gemmill, J. F. *Proc. Zool. Soc. Lond.*, 1915, pp. 1-19 (Starfish); *ibid.*, 1919, pp. 263-265 (Ctenophore); *ibid.*, pp. 459-461 (Lepto-medusa).

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