Flustrella hispida *and its* Development.

By Peter Redfern, M.D. Lond., Lecturer on Anatomy and Physiology, and on Histology, in the University and King's College, Aberdeen.

(Read before the Natural History Section of the British Association, at Dublin, in August, 1857.)

The *Flustrella hispida* of Dr. Gray is the *Flustra hispida* of Fleming, and the *Flustra carnosa* of Dalyell and Johnston. It seems to have been overlooked by Mr. Gosse, in his 'Marine Zoology,' and to have attracted much less attention than it deserves, when its beauty and general distribution are considered.

I have found it abundant on the rocky coast of Kincardineshire, for eleven miles south from Aberdeen; on the Irish coast at Howth, Dalkey, and Bray, in the Bay of Dublin, and at Wicklow; also in North Wales, at Llandudno. It usually grows on the fronds of *Fucus serratus*, but in the immediate vicinity of Aberdeen, it is excessively rare on that Fucus, but abundant on *Chondrus mamillosus*. It forms round or oblong, brown, hairy patches, about a line thick, which extend completely round narrow fronds, but are confined to one side of broad ones. It is invariably encrusting. The extent of the cœnœcium rarely exceeds an inch on the Kincardineshire specimens, but it extends for three or four inches on those gathered in Dublin Bay and North Wales. It occurs on the Fucus, together with the *Alcyonidium hexagonum* (Hinks) and the *Cycloum papillosum* (Hassall); on the specimens of Chondrus the *Flustrella* occurs with *Alcyonidium hirsutum*.

The cœnœcium is thick in the centre; thin, and composed of the last-formed individuals at the edges. The cells radiate from the centre, and they are imbricated in various degrees in different parts, the whole length of the cell, or merely its summit, being visible on the surface. The arrangement of the cells is variable, but generally alternating. When allowed to dry on the plant, the cœnœcium presents the appearance of a wrinkled, hairy membrane; when it is sliced from the plant, and dissected with needles, a large quantity of viscid matter escapes from its cells.

The wall of each cell is set with rigid, reddish-brown, pointed and slightly curved hairs, very numerous, and, for the most part, occupying the whole circumference in the Kincardineshire specimens, but very few in number, and set

in a semicircle over the summit of the cells, in the specimens from Dublin, Wicklow, and North Wales.

In the Kincardineshire specimens, the young cells have five to seven or nine hairs in a semicircle over their summits, and two or three only on each side. The older cells have hairs distributed uniformly over their whole circumference, their lateral septa often presenting eight to twelve or more hairs with their roots closely packed together, one half having their points directed over the cell to the right of the group, the other half having theirs turned over that to its left. One of the lateral hairs on each side often reaches across the cell at the lower margin of its aperture, but no hair of any kind grows in any other position than those above indicated.*

In the specimens from the Irish and Welsh coasts, the summit of the cell has often no more than three hairs upon it, the usual number being five to seven; the sides and base of the cells are often entirely devoid of hairs, the lateral septa occasionally presenting a patch of two or three. So far as I am able to judge from the examination of a large number of specimens, there is always a wide difference in the number of hairs on the Kincardineshire specimens and those gathered further south, this difference being the more remarkable, because an inverse ratio maintains between the number of hairs and the extent of the cœnœcium in the two series of specimens. I am anxious that the attention of naturalists should be directed to this occurrence, because it is possible that the functions of the hairs may be determined by observations of the number and character of the hairs of the same species, growing under different circumstances.

The aperture of the cell is somewhat quadrangular—distinctly so during the protrusion of the polypide. The characters of the cells, their hair sand apertures, are shown in Pl. IV, figs. 1, 2, 3, and 3 *bis*.†

The polypide, when healthy, is easily removed from the cell with its digestive viscera entire, as in fig. 4. The number of tentacles I found to be twenty-eight in all but one of a large number of instances, in which I counted them with

* In old and much imbricated specimens the hairs on the sides and base of the cells are best shown by slicing the cœnœcium from the plant, and dissecting the cells asunder by needles. By this method the polypide may also be easily removed from its cell in so perfect a state that it will live for many hours, showing the effects of ciliary motion more beautifully perhaps than in any other instance whatever.

† The subsequent observations were all made on Kincardineshire specimens.

great care, by the aid of the camera lucida; in the single instance there were twenty-seven. Each tentacle is hollow, covered by a thick layer of ciliated epithelium, easily detached. It is quite remarkable how rapidly these epithelial cells become distended and destroyed when fresh water is added; and as this is the case also with the cells of other parts of the animal, it is not surprising that fresh water instantly destroys it. Fig. 5 represents a portion of a tentacle with its epithelium in the natural state; fig. 6 the tentacle divested of its epithelial covering; and fig. 7 shows the action of fresh water upon the epithelial cells.

The pharynx and œsophagus are lined throughout by ciliated and columnar epithelium. The stomach is separated from the œsophagus by a distinct and complete valve which never allows the alimentary matters to regurgitate. The œsophageal portion of the organ is cylindriform, the body is greatly dilated having a pouch-like dilatation on its great curvature, and being gradually narrowed towards the pyloric aperture, where the stomach can be shut off from the intestine, apparently by a contraction of its muscular wall (pyloric valve). Over the whole of the stomach, the epithelial cells contain a nucleus and deep-red, granular contents. Those of the cul-de-sac, and in the great curvature, and those at the pyloric end, are ciliated; but no cilia are observable in the other parts, nor in any portion of the intestine. The action of the cilia of the stomach is remarkably beautiful when viewed under the microscope, and produces a rapid rotatory motion of the contents of the cul-de-sac, or of the pyloric end, in the axis of these parts respectively.

To the stomach succeeds a dilated portion of the intestine, where the alimentary matters are retained for some time, and converted into elongated consistent pellets. The wall of this portion of the canal has an epithelium, the cells of which contain deep-red granules like those in the stomach-cells, but much fewer in number. Beyond this the intestine is considerably contracted, and its wall becomes so thin that it is often torn during the dissection, in tearing away the tubular sheath of the tentacles, formed of the soft, protrusible portion of the cell. Through this membrane the anus opens externally. I have never noticed the discharge of alimentary matters, except at the moment of protrusion of the tentacles, when the pellet to be discharged escapes from within the crown of tentacles, and commonly falls through between two of them to the exterior.

Muscular system.—The retractor muscular fibres are best seen, *in situ*, in preparations which have been preserved in

spirit, in which they are remarkably distinct. The insertion of the great retractor into the lophophore, the pharynx, and œsophagus, is beautifully seen in the animal removed from its cell by dissection, as in fig. 4.

The great retractor muscle consists of a long cylindriform bundle of fibres, stretching from the deepest part of the cell over the stomach, to reach the œsophagus, pharynx, and lophophore, into which the fibres are inserted. Another bundle of much shorter fibres extends from the side of the cell, near its bottom, to the cul-de-sac of the stomach, into which it appears to be inserted, drawing this part of the organ downwards and towards one side when in action, and thus assisting in folding the parts of the alimentary canal upon each other, that they may be easily accommodated in the interior of the cell. Yet neither these fibres nor any of those of the great retractor muscle remain attached to the stomach of the polypide withdrawn from its cell. I have examined the perfect stomach thus removed in at least twenty instances, and in none have I seen a single fibre attached to the wall of the stomach, whilst, in every case, the torn pharyngeal fibres remain connected with it. Four or five distinct bundles of muscular fibre stretch from the interior of the cell, at different points, to the polypide; passing transversely to the axis of the cell. Other bundles of at least two different muscles extend from the upper part of the interior of the cell to the invaginated portion, which forms the sheath of the tentacles during the retraction of the polypide. The longer of these bundles is so much relaxed during complete retraction, that it is bent upon itself.

During retraction, the œsophageal end of the stomach is rapidly drawn down to the bottom of the cell on one side, the cul-de-sac of the organ to the bottom on the other side; the pyloric end of the stomach is folded upon the upper curvature, the pyloric orifice being brought very close to the œsophageal; the intestine is bent upon the pyloric end until the two lie parallel; and the tentacles are folded in a somewhat spiral manner, close to the intestine which lies by their side. Thus the œsophageal and pyloric ends of the stomach, and the dilated commencement of the intestine, are folded and lie parallel to each other directly across the axis of the cell, in the state of retraction, whilst they lie with their axes parallel to that of the cell, in the state of protrusion of the polypide. The act of retraction is sudden and rapidly completed, like that of voluntary muscles in general; the act of protrusion is performed very slowly, as if the tenta-

cles were gradually distended with fluid, and the body slowly pressed out of the cavity of the cell.

By dissection, ova or statoblasts are obtained in great numbers, presenting the appearances represented in figs. 8 and 10, and consisting of an outer envelope, containing a number of clear and highly refractive nucleated cells, and an opaque, reddish, spherical mass, composed of cells with red granular contents. When some of the contents of these bodies have escaped, their structure is much more easily examined, as in fig. 9. None of those figured possessed cilia. The cilia belong to a membrane, which is placed outside the two capsules figured, and separated from the outer of these by a finely granular mass. Only one of these bodies was observed to have cilia, amongst twenty or thirty carefully examined to determine their presence or absence.

Development.—My reasons for believing that the animal whose development has been examined is the same as the one just described are:—1st, that it grew on the wall of an aquarium, in which there were numbers of specimens of *Flustrella* growing on *Chondrus mamillosus*, and, so far as I could judge, no other which could be mistaken for it; 2d, that on the cell of the second polypide hairs grew of a similar character to those shown in figs. 1, 2, and 3; 3d, the character of the tentacular crown, and the number of the tentacles, as far as it could be determined in a bad position for counting them, and the appearance of the digestive organs, were exactly such as occurred in the creature figured from 1 to 10.

On the 3d of July, 1857, I first observed a solitary polypide in its cell, on the wall of an aquarium. It was apparently in perfect health, alternately protruding and withdrawing its beautiful, bell-shaped crown of tentacles. The elegance of the form of the bell, and the number of its tentacles, led me to compare it with the specimens growing on Chondrus in the same vessel, and the result was, that I could find no difference between them. On this occasion I did not notice any projection of the wall of the cell for the formation of a gemma.

On the 4th of July, a definite projection of the wall was observed (fig. 11); two days later the projection had increased in size considerably, and it presented externally a protruded portion of the wall of the original cell, and in its interior a striation slightly radiating towards the surface, the striæ being produced of rows of highly refractive globules (fig. 21.) On the evening of this second day, the body of the polypide was visible, as a small cone, at the deepest part of the

striated mass, and on the third day it had become much more distinct, whilst the gemma appeared to be encroaching on the old cell, and the striated mass had approached the surface (fig. 13). With a view of facilitating the examination, a small mirror, the framework of which had been recently coated with gold size, was introduced into the aquarium. Shortly afterwards, the tentacles of the polypide (fig. 11) were observed to be bent at various angles, and to hang loosely, as if they had been broken, resuming their natural appearance at intervals. The polypide protruded itself but rarely, and never recovered its healthy characters, dying four days subsequently. I believe that it was injured by the gold size.

On the fourth day of the formation of the gemma, it presented a yellowish striated band at its deepest part, apparently the first trace of its retractor muscle. On the same day, traces of the formation of three other gemmæ were seen, as in fig. 14, but their development was speedily arrested, and they were not again observed.

On the seventh day, the new polypide presented the form of a bent tube, the striation near the surface remained, and between it and the bent canal, representing the body of the animal, there was a clear space faintly separated into bands by indistinct striæ (fig. 15). These ultimately became the tentacles. On this day, four distinct and blunt hairs were observed to have formed on the wall of the cell of the new polypide.

On the eleventh day, the gemma had considerably increased in size, and presented a nipple-like membranous prominence. The polypide was observed shrinking in its cell on the application of a bright light. The hairs, which were blunt at their ends on the seventh day, had become pointed. The perigastric space was quite distinct. The refractive globules, producing the striation near the surface, had gradually diminished in number, and formed a thin layer between the tentacles and the surface. This state was figured on the twelfth day, as in fig. 16.

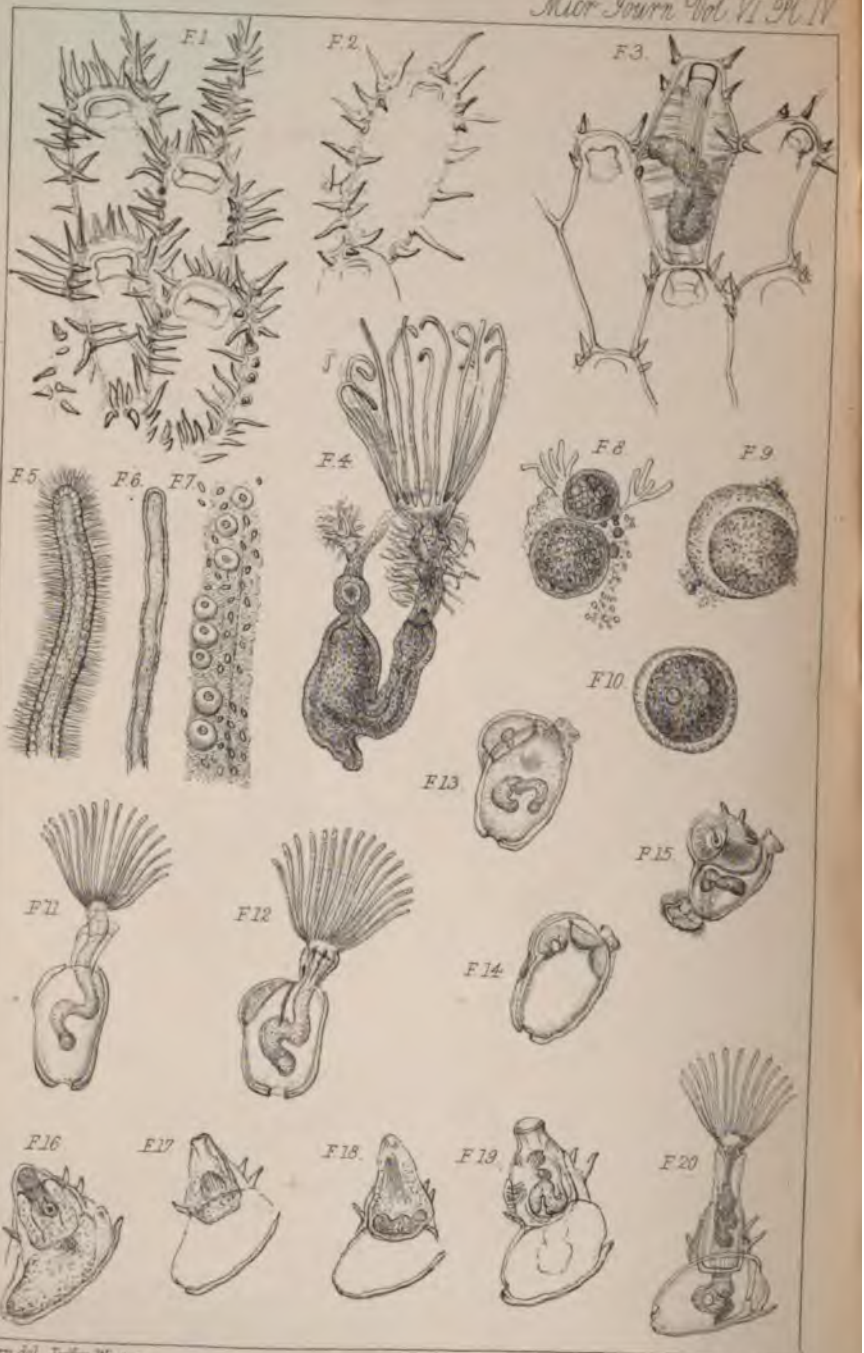
On the thirteenth day, the apex of the cell had become much thinner, and presented the appearances represented in the drawings (figs. 17 and 18), sketched by the aid of the camera lucida, when the polypide was retracted and protruded. The tentacles were much longer and more distinct, the rows of highly refractive globules between the tentacles and the surface were greatly diminished in number and size, and the perigastric space was clearer. The condition of the polypide at this time is so graphically described by the Rev. T. Hincks,

in a paper in the eighth volume of the 'Annals and Magazine of Natural History,' that I can add nothing to his account of it. I regret that I was not aware of the existence of this paper until after my opportunity of observing the creature had passed away. Mr. Hincks says:—"Imperceptibly the body of the polype shapes itself within the mass. The tentacles are first visible.* Soon violent convulsive movements are seen within. The front part of the cell is frequently pushed out with much apparent force, so as to form a neck of considerable length, and then suddenly retracted. There is no appearance of an opening at this time. The tentacles become very restless, and bend themselves about as if trying their powers, and impatient of confinement. Gradually the parts become more defined; the elongation and retraction of the fore part of the cell continue, and, at length, the polype breaks from its captivity."

On the fifteenth day, the polypide protruded fully, and its tentacles expanded freely. The wall of its cell was beautifully transparent, and admitted a full examination of the viscera, now receiving the alimentary matters. On the seventeenth day, the drawings 19 and 20 were made. In the state of protrusion, the lophophore and anus were carried outwards, and the alimentary canal stretched, owing to the stomach being drawn but little away from the bottom of the cell, whilst the other parts were shifted extensively. Ciliary motion was distinct on all the parts on which it is observed on the adult polypide. In the state of retraction, the quadrangular state of the aperture of the cell was distinctly observed; the tentacles were folded somewhat spirally upon each other; the œsophageal end of the stomach was drawn down to the bottom and side of the cell, and the pyloric end folded over it, the pyloric orifice being carried towards the same side, together with the dilated commencement of the intestine, which was laid parallel to the pyloric end of the stomach, and directly across the direction of the cell.

Some appearance of the formation of a gemma occurred on the wall of this second cell, as in fig. 20, but it became no further developed, and the second polypide itself was found dead on the twenty-seventh day of its existence, to my very great regret.

* When I first saw the striated mass beneath the surface of the gemma I supposed that it was the early stage of the formation of the tentacles, but I subsequently found that they formed beneath it, and that they were not distinct until after the body of the polypide had assumed the decided form of a bent tube.


F1.
F2.
F3.
F4.
F5.
F6.
F7.
F8.
F9.
F10.
F11.
F12.
F13.
F14.
F15.
F16.
F17.
F18.
F19.
F20.

DESCRIPTION OF PLATE IV,

Illustrating Dr. Redfern's paper on *Flustrella hispida*.

Fig.

1.—Cœnœcium of *Flustrella hispida* removed by horizontal section from the frond of *Chondrus mamillosus*.

2.—Ditto, ditto, showing cells with fewer hairs on their sides and a more imbricated arrangement.

3.—A single cell of the same separated from those which surrounded it. Figs. 1, 2, and 3 magnified.

3 *bis*.—Cœnœcium of a specimen gathered on the coast of North Wales.

4.—Polypide removed from its cell, showing its digestive viscera.

5.—Portion of a tentacle, showing the natural state of its investing ciliated epithelium.

6.—Ditto, denuded of its epithelium.

7.—Ditto, showing its epithelial cells distended by fresh water. Figs. 5, 6, and 7 magnified.

8 to 10.—Unciliated ova or statoblasts densely filled with cells.

9.—Ditto, from which some of the cells have escaped, showing the remaining contents more distinctly cellular. Figs. 4, 8, 9, and 10 magnified.

11.—A single polypide in its cell, with a gemma forming on its wall.

12.—The same after two days, showing a striation produced by rows of highly refractive corpuscles.

13.—Ditto, on the third day, showing the polypide like a bud at the bottom of the new cell.

14.—Ditto, on the fourth day, showing traces of the formation of three other gemmæ.

15.—Ditto, on the seventh day. The polypide has assumed the form of a bent tube; the cell has four well-marked hairs formed on it; one only of the other gemmæ is now distinctly seen.

16.—Ditto, on the twelfth day. The projecting part of the cell has become flexible and greatly more prominent; the wall of the perigastric space and the tentacles are quite distinctly seen; no other gemma is distinctly visible.

17 and 18.—Ditto, on the thirteenth day, showing states of retraction and protrusion. The movements are now remarkably distinct, the tentacles much longer, the perigastric space clearer, the rows of refractive globules greatly diminished in number and size.

19 and 20.—Ditto, on the seventeenth day, showing the whole digestive system beautifully distinct, as well in the state of retraction as of protrusion; a gemma appears to be forming on the side of the newly developed cell.