

e, Thorns, brambles, or furze, surrounding the pole, to secure it from injury.

Note.—That part of the wood which enters the earth should be charred, to preserve it from moisture; while the remainder of the pole may be varnished, the better to secure its non-conducting character. The varnish of *Lampadius*, composed of a mixture of *linseed oil*, *sulphate of copper*, and *lead*, will be found remarkably good for this purpose.

*Observations on the Structure and Nature of Flustræ**. By R. E. GRANT, M.D., F.R. S. E., F. L. S., W. M. S., formerly Lecturer on Comparative Anatomy in Edinburgh. Communicated by the Author.

THE regular forms of the cells of *Flustræ*, their close and exact arrangement, and the elegant foliage which they form by their union, early attracted the notice of naturalists; and the great flexibility, transparency, and ramified appearance of these substances, caused them to be universally regarded as marine plants, till Jussieu, by his discovery of the polypi of the *Flustra foliacea* (*Mem. de l'Acad.* 1742), assigned them a place in the animal kingdom. The interesting observations of Jussieu on that species, of Læfing on the polypi and formation of the new cells of the *F. pilosa*, Ellis on the structure and forms of the cells of many British species, Basterus on the spontaneous motions of the small bodies which escape from the apertures of the cells, Pallas on the mode of formation of the cells and on the nature of the bullæ at their summits, and of Spallanzani on the structure and appearance of the polypi, have shewn that these animals possess a highly complicated organization, and have some of the characters of compound animals or zoophytes. Ellis has shewn that the forms of the cells vary remarkably in different species, presenting an obvious and useful character for their discrimination; and nearly forty species of these animals, recent and fossil, are described by authors. No writer, however, has yet examined the minute structure, the mode of growth, and the

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mode of generation of *Flustræ*, with sufficient detail, either to comprehend the history of a single species, or to determine the true nature of the genus. The most accurate observers have unfortunately confined their observations to the skeleton, while those who had opportunities of examining the soft parts, in the living state, have been blinded by preconceived hypotheses, and their observations are neither minute nor correct. The accurate and minute observations of Ellis and Pallas relate solely to the axis. Basterus examined these animals frequently alive on the coasts of Holland, and often saw the ova moving to and fro spontaneously on escaping from the cells; but, as he maintained that the polypi of all zoophytes are merely species of vermin infesting the surface of aquatic plants, he naturally considered these moving bodies, both in *flustræ* and in other zoophytes in which he likewise observed them, as polypi which had left their habitations, to swim about for a time in search of prey, and again returned to their cells. Spallanzani observed the polypi bent like a bow in their cells, and supposed them connected to the cells by their lower extremity; he remarked the bell-shaped arrangement of the tentacula around the mouth, and the constant currents towards that orifice,—but he did not perceive the ciliæ placed on the two lateral margins of the tentacula, and imagined the currents to be produced “by the constant agitation of the arms.” The same function has been erroneously ascribed to the tentacula by most authors, and the number of these organs in any species has not been accurately ascertained. A very slight observation is sufficient to shew that the cells of *flustræ* are more isolated than they are in most zoophytes, and that the lower part of the polypus is not continuous with a central fleshy axis, as it is in *Sertulariæ*, *Plumulariæ*, *Campanulariæ*, and many other keratophytes. This circumstance early led to an opinion that the polypi of *flustræ* have no connection with each other, and that the whole substance consists only of a congeries of independent cells. This opinion was strengthened by the statement of Læfling, that, when one polypus of the *F. pilosa* is touched, the neighbouring polypi are not affected, and that, in advancing from their cells, they advance without order or regularity. It is likewise stated by the same observer, that the new cells, placed around the margins of the branches, are

formed by the development of bodies which are protruded from the old cells contiguous to them; and that, in the middle space, between the margins of the branches, we find the old polypi, for the most part, dead, or entirely removed from the cells. These views regarding the nature of *Flustræ*, seemed to be confirmed by the statement of Basterus, that the polypi have no connection with the cells, and occasionally leave them entirely to seek for nourishment; and by the remarkable fact stated by Jussieu, that, after having retained a living *flustra* for a few days in a vessel of sea-water, he observed that all the *polypi* had left their cells, and lay motionless at the bottom of the vessel. There can be little doubt, from what I shall state hereafter, that this appearance, observed by Jussieu, consisted of the escape of the *ova* from their cells, and probably their fixing themselves on the bottom of the vessel. I have found them often fix themselves permanently on watch-glasses in less than six hours after their escape from the cells. Basterus quotes Rœsel as having likewise observed the polypi to swim to and fro after leaving the cells, (Bast. Opusc. sub. p. 61., and Rœsel. Supp. p. 605.) The same sentiments are still entertained by the most distinguished naturalists, both regarding the independent nature of the cells of *Flustræ*, and their mode of formation by the successive development of small vesicles or gemmules which have fallen from the mouths of the old cells. Lamouroux states (*Hist. des Polyp.* p. 99), that, when the polypus of a *flustra* has attained its full size, it discharges through the opening of its cell a small globular body which attaches itself near that aperture, increases in bulk, and soon assumes the form of a new cell. Lamarck maintains (tom. ii. p. 154.), that the polypi of these animals have no communication with each other, no common connecting substance, and “do not form compound animals;” that the gemmutes, or reproductive vesicles, after detaching themselves, fall into a determinate position beside the other cells; that each polypus probably perishes after producing a single vesicle, and that the polypi are hence likely to be found alive only near the outer margins of the branches. As the branches of *Flustræ* almost always expand in breadth from their base to their free extremity, by the successive interposition of new rows of cells, which continually disturb the parallelism of

the older rows, and cause them to diverge outwards, Pallas imagined (*Elench. Zooph.* p. 34.) that sometimes the same cell discharges two reproductive gemmules. And as we always observe the first cell of a new row small and deformed, he imagined that the two gemmules were discharged at different times, and that the second never arrived at a perfect state. We are still far from being sufficiently acquainted with the intimate structure and economy of animals thus low in the scale, to predict, from the appearance of their dried axis, what may be the real nature, the mode of growth, or the mode of generation of *Flustræ*; but it is very obvious, that if the generally received opinion, that they are not compound animals, prove correct, they ought no longer to be placed among zoophytes, whose polypi are always connected together by a common axis, so as to form compound animals, the whole of whose parts are animated by one common principle of life and growth.

The chief difficulties in examining the living phenomena of *Flustræ*, and which have probably retarded our knowledge of the structure and economy of these beautiful marine productions, are the extreme minuteness, the shyness, and the complicated structure of the polypi; the quantity of earthy matter in the parietes of the cells, rendering them somewhat opaque; the circumstance of the most common branched species, as the *Flustra foliacea*, *F. truncata*, &c. having the cells disposed in two opposite planes, which are closely connected to each other, back to back, and which prevents the accurate examination of these branched species under the microscope by transmitted light; and the circumstance of the sessile species being fixed immovably on the surface of solid bodies, whose opacity likewise prevents their minute examination by transmitted light. The numerous species of *Flustræ* in the Frith of Forth, and their great abundance, both in deep water and near the shore, present a very favourable opportunity of examining the recent structure, and watching the living phenomena, of these animals at all seasons of the year; and a careful examination of a single species, would not only illustrate the history of this numerous and obscure genus, but would likewise throw much light on the equally unknown nature of *Cellepores*, *Discopores*, *Tubulipores*, *Escharæ*, and some other nearly allied calcareous zoophytes. The

species of *Flustræ* most abundant in the Frith of Forth, and from which the following observations have been chiefly taken, are the *F. foliacea*, a branched species with a double plane of cells and two projecting spines at each side of the apertures of the cell; *F. truncata* a very delicate branched species, with a double plane of cells disposed in longitudinal straight lines, the sides of the cells are nearly straight and parallel, and have no projecting spines; *F. carbacea*, a delicate, broad leaved, branched species, with a single plane of large transparent cells, without projecting spines; *F. dentata*, a sessile species, with a single plane of cells, generally incrusting the leaves of large fuci, the margins of the cells are surrounded with numerous short projecting sharp calcareous spines; the *F. pilosa*, a delicate sessile species, the apertures of whose cells are defended only by a single long curved spine, it generally encrusts the stems of the smaller fuci or the branches of zoophytes; and the *F. telacea*, a sessile species, with long quadrangular cells covering the leaves of large fuci, the cells having two short spines at their summit.

When we look through a branch of the *F. foliacea* or other species of *Flustra*, which has a double plane of cells, we find that the boundaries of the cells on one side, do not coincide with the boundaries of those on the opposite plane; the position of the cells on one side of the *Flustra* has no relation to those on the opposite side, and the appearances, presented by the contiguous cells on the opposite sides, are often totally different, the cell on one plane presenting a polypus in full activity, while the contiguous cell on the opposite plane presents an ovum arrived at maturity, with the remains of a decayed polypus nearly absorbed. This not only produces a confused appearance in the cells, but likewise diminishes their transparency; and although, in such species, we can tear the two planes of cells separate from each other, this is generally attended with injury both to the cells and their contents. Such species, therefore, though the largest, the most abundant on our coasts, and those which have been most frequently examined, are ill adapted for the commencement of an inquiry of this kind, and the sessile species, which spread as a crust on the surface of opaque bodies, are still more unsuitable. The *F. carbacea* of Ellis, Lamouroux, Lamarck, &c. is a branched species, which not only has the advantage of being very common on our coasts, and of having the cells arranged in a single plane, but likewise of having the cells of a large size, and very transparent, from the small quantity of lime in their parietes. This species is not found near the shore like the *F. dentata*, *F. pilosa*, and *F. telacea*, but is brought up in great quantities during the dredging season, from almost all the oyster-beds of the Frith of Forth, where it is found in ramified tufts, from two to four inches high, adhering by a very narrow base to the surface of shells, stones, fuci, and even of the smallest

zoophytes. Its branches are broad, thin, semitransparent, studded with small reddish-brown spots, generally dichotomous, often trichotomous; the trunks of the branches have thick, yellow, opaque margins, and their free extremities are very thin, membranous, transparent, and rounded or lobed. In the dried state the branches have a glistening membranous surface, they produce distinct effervescence, and coil up when touched with nitric acid, indicating the presence of carbonate of lime in the horny texture of their cells. They are so delicate that we rarely find a specimen in which the branches are not broken at their extremities, or perforated with ragged holes, and they are very often studded on both sides with small patches of the *Flustra dentata*, in the same manner as the *Flustra foliaca* is very much infested in the Frith of Forth with creeping branches of the *Cellaria reptans*. There are no tubular roots in this species as there are in the *F. truncata*; the compact base is formed of condensed cells, which originally contained polypi. The polypi are deficient near the base, as in other flexible branched zoophytes, from the constant bending and pressure at that part, which gradually extend and approximate the sides of the cells, and thus render the stems more compact, flexible, and strong, to sustain the increasing weight of the branches, and consequent increased influence of the waves. This takes place likewise in the stems of branched zoophytes without polypi, and may be compared to the condensation of cellular substance into membrane and ligament in higher animals. It is by rearing the ova of this species on the surface of watch-glasses, that I have found its first formed parts to consist of polypiferous cells, and not of tubular roots, as in many other zoophytes, although the same may be ascertained by a careful examination of these hard parts. The cells are arranged with remarkable exactness, in perpendicular straight lines, and in curved rows diverging on each side to the margin. It appears much more important in the economy of a flustra to preserve this exact arrangement, than to perfect the forms of the individual cells, as we often observe the cells at the commencement of the new rows assume a small and distorted form, in order to adjust them to the precise line of arrangement of the neighbouring cells. The cells are all nearly of the same size, in whatever part of the branches we observe them, and whether on young or old, large or small specimens. The cells are about a third of a line in length, and half as much in breadth. They are widest in the middle, slightly tapering and arched at the summit, and contracted to about a third of their breadth at the base. They open by an arched and folding aperture near their wider extremity, and all the apertures are placed on the same side of the branch, which is probably the most pendent in the natural state. As the cells have only one aperture, and are arranged in a single plane, we find one side of the branches in this species entirely free from apertures; this shut side of the branches is the most frequent seat of the *Flustra dentata*, but the side containing the apertures is likewise often attacked by this parasitic species. The anterior part of the cell consists of a thin transparent membrane. The margins of this membrane are supported and protected by several fasciculi of straight slender calcareous *spicula*, which are attached to the solid sides of the cell, and extend inwards along the surface of the membrane. These spicula are all of the same size and form; they are less than the tenth

part of a line in length, of equal thickness throughout, round at their free extremities, and dissolve with effervescence in diluted nitric acid. They are not perceptible without the aid of a microscope. The spicula are arranged along the whole of each side of the cell; they are placed in nearly parallel groups, of three or four, at short distances from each other, and are most numerous at the middle of the cell where the principal part of the polypus is usually coiled up in a spiral turn.

In the newly formed cells at the extremities of the branches, we at first observe the spicula only at the part of the cell where the body of the young polypus is still entirely shut up in a sac. The cell is usually shut, or nearly shut, at the top, in the retracted state of the polypus, but opens by a kind of semilunar valve, with firm margins, when the polypus is advancing out from the aperture. The back of the cell is formed by a transparent tough membrane, which contains some opaque spots of calcareous matter, and exhibits numerous transparent branched lines, like vessels or fibres, running chiefly in a longitudinal direction. When the polypus is dead, and nearly absorbed, many of these vessels are seen radiating from the last remains of the polypus, which appear as a small red or brown spot in the centre of the posterior wall of the cell. The lateral walls of the cell appear to consist of a thin calcareous lamina, lying perpendicularly to the general plane of the cells, it is white, and very tough; and, when highly magnified, it exhibits fibres or vessels, running longitudinally on its surface. Mr Ellis supposed the lateral walls of the cells of *Flustra* to be formed by a tube. When we look perpendicularly on this part, it appears as a white filament; but when viewed laterally, we observe it to consist of a regular thin plate, surrounding the whole margin of the cell. By examining carefully with the microscope the margins and corners of the cells, we observe, that there is a thin transparent membranous lining within the walls of the cell. In the young cells, this internal lining forms a small shut sac at the bottom of the cell, in which the infant polypus is inclosed and matured: this sac gradually extends to the aperture of the cell through which the polypus at length protrudes its tentacula; and, at last, it is found nearly applied to the walls of the cell. The particles of sand and other matter, which sometimes appear to be within the cells, are generally on the outside, adhering to the posterior wall.

The polypus of the *F. carbacea* is nearly twice as long as the cell which contains it, and when retracted within the cell, it is found coiled up in a spiral turn, extending from the aperture to the base of the cell. The polypus consists of the tentacula, the head, the body, and a large globular appendix, attached to the posterior part of the body. The tentacula are usually twenty-two in number, sometimes we observe only twenty-one; they are long, slender, cylindrical, of equal thickness throughout, and have each a single row of ciliae, extending along both the lateral margins from their base to their free extremity. The tentacula are nearly a third of the length of the body of the polypus, and there appear to be about 50 ciliae on each side of a tentaculum, making 2200 ciliae on each polypus. In this species there are more than 18 cells in a square line, or 1800 in a square inch of surface, and the branches of an ordinary specimen present about 10 square inches of surface; so that a common specimen of the *F. carbacea* presents more than 18,000 polypi, 396,000

tentacula, and 39,600,000 ciliae. From the smallness of the cells of the *F. foliacea*, the immense number and size of the branches, and the cells being disposed on both sides of the branches, the above calculations are often ten times greater in that species. When the polypus is stretched out from its cell the tentacula remain stiffly expanded in a bell-shaped form, their free extremities being all equally reflected outwards; and it is somewhat remarkable, that when the polypi are torn from their cells and examined, quite dead, in fresh water, the tentacula remain in the same stiff expanded form. The tentacula are exquisitely sensible, and we frequently observe them, either singly or all at once, striking in their free extremities to the centre of the bell-shaped cavity, when any minute floating body comes into contact with them. When the polypus is expanded, there is a constant current of water towards its mouth, produced by the rapid vibrations of the ciliae of the tentacula. The ciliae move by far too rapidly to be followed by the quickest eye, aided by the most powerful microscope, and their motions are quite regular, ascending along one side of the tentaculum, and descending along the other, like a current. These regular motions appear more like some physical phenomenon than any movements depending on volition, as I have just shown, that an ordinary sized specimen of this animal can vibrate nearly 40,000,000 of ciliae at the same instant with this incalculable velocity,—an exertion of volition altogether inconceivable in an animal which exhibits no trace of a nervous system. All the ciliae of a polypus appear to commence and cease their motions at the same time. The bases of the tentacula are inserted into the outer margin of a broad prominent lip surrounding the mouth of the polypus. When the polypus is withdrawn into its cell, the tentacula form a close straight fasciculus quite distinguishable, like every other part of the polypus, through the transparent sides of the cell. The head of the polypus into which the tentacula are inserted, is a little more dilated than the rest of the body, and rounded; and from the incessant revolution of particles observed within it, this part seems to be ciliated internally, like the sides of the tentacula. The head has the power of dilating itself by a sudden stroke, which is probably produced by the sudden retraction of the prominent sides of the mouth, when they have seized an animalcule. The tentacula and the head are of a white colour, and the rest of the body is generally of a yellow, or sometimes of a blood-red colour. We observe a fibrous capsule descending from the whole margin of the aperture of the cell, to be inserted around the body of the polypus a little below the head. This part is probably destined to aid the polypus in advancing from the cell, or to protect the interior of the cell from foreign matter. From the same part of the polypus numerous distinct fasciculi of soft fibres descend, to be inserted into the base of the cell; these appear destined to retract the polypus into the cell. These fibres appear very much corrugated and interwoven at the bottom of the cell, when the polypus is entirely withdrawn into its cavity. The body of the polypus is a long cylindrical fleshy tube of equal thickness throughout, to near its extremity, where it tapers a little. The body, after extending to the bottom of the cell, makes a curve backwards, and again upwards to the centre of the cell, where the posterior extremity is bent forward, and to one side. From the part of the body which ascends to the centre of the cell, about a sixth from the posterior end of the polypus, a

fleshy tubular process is sent off, which terminates in a large oblong fleshy sac, generally filled with some opaque matter. As this process is nearly as thick as the part of the body from which it comes, the polypus appears bifurcated at its shut extremity. At the point of the bifurcation, the polypus appears to be somehow connected with the centre of the posterior wall of the cell; and every other part of the polypus, excepting this, moves freely in the cavity of the cell. The last remains of the dead polypi are found at this point of the cell, with vessels radiating from them. From the point of the bifurcation to the entrance of the round sac, we perceive a kind of circulation continually going on within the fleshy tube; it consists in the constant revolution of the particles of some fluid, probably caused by ciliæ disposed on the internal surface of the canal. The tapering or posterior part of the body of the polypus sometimes exhibits small portions of digested matter passing to and fro within it. The round shut sac containing the opaque yellow matter moves often, and quite freely, within the cell; and it appears to belong rather to the digestion than to the generation of this animal, as it communicates directly with the digestive canal of the polypus, and it will be seen that the polypus of this animal has as little to do with the formation and growth of the ova, as it has in other zoophytes.

In place of finding the polypi alive only near the margins of the branches, as Lœfling, Lamark, and others have maintained, we find them almost equally abundant and healthy in every part, from the base to the apex, and from the centre to the margins of the branches. The cells along the sides of the branches are generally imperfectly formed, and contain no polypi; their outer calcareous margin is for the most part wanting. The last two or three rows of cells, at the extremities of the branches, are thin, soft, gelatinous, and transparent; and contain young polypi so imperfectly formed, that it is quite obvious that the extreme row could not have been generated by the polypi of the second row, after their arriving at maturity. The extreme margin of the branches always presents a smooth and even outline from the equal growth of every point of the axis, and never exhibits the notched or serrated line, which would be produced by the unequal developement of a terminal row of gemmules. The cells newly formed in the soft gelatinous terminations of the branches, have the same size and form as the oldest cells, so that we find at the extremities of the branches a row of imperfect cells in every stage of their formation. Some of these imperfect cells do not yet exhibit the rudiments of a polypus; some a little further advanced exhibit an opaque spot at the base, from which tentacula at length shoot out like buds; other cells, more nearly completed, present the young polypus inclosed in a long shut sac, tapering upwards to the point where the aperture of the cell is afterwards formed; and others, which only want their upper arched wall, contain perfectly formed polypi, capable of projecting their tentacula and head through the opening of the cell; their parts are very transparent and colourless, and their globular appendix appears empty. The sides of the cells form continuous, ramified, and waved lines, from the base to the apex of the branches; and the growth of the axis in this, as in every other zoophyte, precedes the growth and formation of the polypi. The *axis* of this zoophyte consists in the parietes of the cells, and it

presents, in every stage of its growth, a regular form, and exact proportions in all its parts; it is composed of a continuous fleshy and calcareous substance, like the outer part of the axis of the gorgonia, which the beautiful experiments of Cavolini have shewn to be by far the most highly organised part of that zoophyte, possessing distinct irritability, and secreting the horny layers of the central part of the axis. The polypi are most intimately and inseparably connected with the axis by three parts of their body, and are only digestive sacs or mouths developed by the axis, as in all other zoophytes, for the nourishment of the general mass. By the *axis* of a zoophyte, I understand every part of the body excepting the polypi, whether of a calcareous, horny, or fleshy nature. The exact mathematical arrangement and forms of the cells of *Flustræ*, is incompatible with their existence, as separate and independent beings, but is quite analogous to what we are accustomed to observe in *Cellariæ*, *Sertulariæ*, *Plumulariæ*, and many other well known compound animals.

Although the *ova* of *Flustræ* have been often observed, no one appears to have hitherto examined either their mode of formation within the cells, or their mode of developement after expulsion, so as to determine the real nature of these globular bodies, and the erroneous conjectures of naturalists respecting them have greatly perplexed the history of this genus. The *ova* of the *F. carbasea* make their first appearance as a small yellow point, a little below the aperture of the cell, and behind the body of the polypus; they are unconnected with the polypus, and appear to be produced by the posterior wall of the cell, in the same manner as the axis, or common connecting substance of the polypi, produces them in other zoophytes. In this rudimentary state they are found in the same cells with the healthy polypi, but, before they arrive at maturity, the polypi of such cells perish and disappear, leaving the entire cavity for the developement of the ovum. There are never more than one ovum in a cell, and it occupies about a third of the cavity, when full grown and ready to escape. When first visible it has a round or slightly oblong and regular form; when mature, it is ovate with the small end next the aperture of the cell. The *ova* do not appear in all the cells at one time, nor is there any discernible order as to the particular cells which produce *ova*, or the part of the branch which contains them. Cells containing *ova* are found alike on every part of the branches, from the base to within two or three rows from the apex, occupied only by young polypi. Sometimes we find half a dozen or a dozen of contiguous cells all containing *ova*, sometimes two or three only; and often such cells occur singly, at short and irregular distances from each other. We find the *ova*, in all stages of maturity, on the same branch at the same time; and we seldom observe a specimen of the *F. carbasea*, during the months of February, March and April, which does not contain numerous *ova*. The *ova* have a lively yellow colour; and when they occur abundantly on a specimen or a part of a branch, they cause it to exhibit the same lively hue, which is very different from the dull spotted brown appearance which the branches present at other seasons. Cells are often observed on different parts of the branches, containing neither polypi nor *ova*; but the fewness of these, and the great number of cells still containing only polypi at the season of generation, render it probable that polypi are regenerated in the empty cells after the escape of the *ova*. In the empty cells from which the

ova have escaped, we frequently observe a few remains of the former polypus lying at the place where the body of the polypus bifurcated, and where the principal connection seems to exist between the polypus and the axis; we likewise perceive numerous monades and other animalcules busily employed in consuming the remains of the dead polypus. The ovum, even before arriving at maturity, exhibits very obvious signs of irritability, frequently contracting different parts of its surface, and shrinking backwards in its cell; the ciliæ on its surface are likewise observed in rapid motion within the cell, as in the ciliated ova of other zoophytes. The mature ova are often found with their small end projecting from the opening of the cells, and their final escape is aided by the incessant vibrations of the ciliæ covering their surface, by the ova contracting themselves in their lateral direction, by the waves agitating the branches of the *flustra*, and by the same incomprehensible laws which regulate the formation and growth of the ova, and the whole economy of this zoophyte.

When the ova of the *F. carbasea* have escaped from the cells, and are observed swimming to and fro in a watch-glass with sea-water under the microscope, we perceive that the small end which first escaped from the cell is carried foremost, and the broad posterior end has now expanded into a broad circular zone, giving a flatness to that extremity. The ciliæ are longest in the centre of the broad extremity as in other ova*, and become gradually smaller towards the narrow end. When torn and examined on a plate of glass under the microscope, the whole ovum appears composed of very minute gelatinous granules or monade-like bodies, without any external capsule or internal calcareous matter. They are very irritable, and are frequently observed to contract the circular margin of their broad extremity, and to stop suddenly in their course when swimming; they swim with a gentle gliding motion, often appear stationary, revolving rapidly round their long axis, with their broad end uppermost; and they bound straight forward, or in circles, without any other apparent object, than to keep themselves afloat till they find themselves in a favourable situation for fixing and assuming the perfect state. The time of their remaining in this free and moving state varies from a few hours to about three days, according to circumstances. When placed in a watch-glass, immersed in a vessel of pure sea-water recent from the sea, and kept in the cavity of the glass, by a careful management, they generally fix within the space of six hours from the time of their escape from the cells. The slightest agitation when they are about to fix, causes them to recommence, and continue for some time, their gliding motions; and if again separated from the surface of the glass when they have begun to fix, they generally remain free, and perish. During the process of fixing, they exhibit no peculiar appearance or change of form; they appear simply to lie on their side, and the ciliæ continue to vibrate over the whole surface, producing a constant current in the water, and clearing the space immediately surrounding the ovum; on agitating gently the water, however, we now find that it can no longer move from its place. I have found the ova of the *F. carbasea* remain three days in this fixed recumbent position without undergoing any perceptible change of form,

* See Edinburgh New Philosophical Journal, December 1826, p. 129.

and without relenting the motions of the ciliae on their surface. About this time from their fixing, the ciliae cease to move, and disappear, first at a particular part of the surface, and in the space of twenty-four hours longer they cease their motions over the whole surface of the ova. In about two days after the ciliae have ceased to move, the ovum appears more swelled, the surrounding margin becomes more transparent and colourless, and the yellow matter, which appeared to compose the whole ovum, is now confined to the central part. As the ovum enlarges and loses its bright yellow colour, it assumes a form more nearly resembling that of a cell, and acquires a light grey or whitish colour, with increased transparency in every part, excepting the yellow central spot, which gradually diminishes in size. A delicate white opaque line makes its appearance near the outer margin of the transparent ovum, and passing round its whole circumference; this white line has the form and nearly the size of a full-grown cell, and is the rudiment of the lateral calcareous wall of the cell. Towards the base of this rudimentary cell, we perceive the gelatinous interior become more consistent and opaque at a particular point; from this dull spot within the cell we soon perceive short straight tentacula begin to bud out, extending upwards in the direction of the future aperture. The gelatinous spot from which the tentacula originated, assumes the vermiform appearance of the body of a polypus, and we distinctly perceive the bundles of fibres which connect its head with the base of the cell. The aperture of the cell, in form of a crescentic valve, is perceptible before the infant polypus extends so high in the cell, and is not a mere perforation made by the polypus, as Lamouroux and some others have supposed. The structure of the polypus is perfected within a distinct shut capsule, and when we first detect it protruding from the cell, it possesses all the parts of an adult polypus, and vibrates the ciliae of its tentacula with as much regularity and velocity as at any future period. Before the polypus is capable of protruding from the aperture of the first cell, we perceive the upper part of that cell extending outward to form the rudiment of a second, in the same manner as we observe at the tips of the branches in adult specimens,

(To be concluded in next Number.)

Some Remarks on the Temperature and Climate of Shetland.

By WILLIAM SCOTT, A. M., of the Royal Military College at Sandhurst.—Communicated by the Author.

AT the request of Professor Jameson, I drew up a set of Tables, exhibiting the temperature, wind, and weather, during part of the years 1824 and 1825, as observed by myself at Belmont, in the island of Unst, Shetland, in Long. $0^{\circ} 51'$ West, Lat. $60^{\circ} 42'$ North, the thermometer being elevated 66.2 feet above the level of the sea, and 300 yards distant from it. These tables, however, prove too bulky for insertion in the Philoso-

that as a genus, it rests on very insufficient grounds. The tree, however, is evidently related either to *Ficus* or *Brosimum*. The juice contained in the phial sent to Mr Lambert had the appearance of sour cream, and, notwithstanding that it had suffered materially from the long voyage, the taste was by no means unpalatable.

To prevent any misconception of the method taken to increase the female Nutmeg, it may be proper to remark, that, by inarching, he means inarching the branches of the female tree on the young plants produced from seed, by which mode a certain supply of female trees is obtained; whereas from seed, several years must elapse before the trees produce flowers, and then the result must be frequently disappointing; more especially if the disproportion between the number of male and female trees from seed be so great as Mr Lockhart has observed. A very few male trees will be found sufficient for a whole plantation of females. I do not remember of any other instances on record of an absolute change of sex, than the striking ones mentioned above by Mr Lockhart, as occurring in the nutmeg tree. It is a fact well deserving the attention of physiologists. Individual plants, producing at the same time male and female flowers, are of common occurrence.

Observations on the Structure and Nature of Flustræ. By R. E. GRANT, M.D. F.R.S.E. F.L.S. M.W.S. Fellow of the Royal College of Physicians of Edinburgh, Prof. of Zoology in the University of London, &c. (Continued from p. 118.)

IN examining the anatomy of the other species of *Flustræ* above mentioned, more care is required than in the examination of the *F. carbacea*, as the two plains of cells composing the branches of the *F. foliacea* and *F. truncata* require to be carefully separated from each other, and the sessile species, *F. telacea*, *F. dentata*, and *F. pilosa*, require to be removed from the surface of the fuci, or other substances to which they adhere, in order to render them sufficiently transparent to allow their minute structure to be perceived through the reflecting microscope. The *Flustra foliacea*, Lam., like the *F. carbacea*, already described, is an inhabitant of deep water, and is very rarely met with in a fixed situation near the shore, or in places

accessible at ebb tide, though, from the immense quantities of it which I have found drifted alive on our eastern and western coasts, and constantly brought up by the dredges from oyster-beds, it appears to be the most abundant species on the British shores. It generally adheres to shells or stones, on the surface of which it first spreads like a sessile species with a single plain of cells, then rises up in the centre of the expanded base in a branched form, when its branches are always composed of a double plain of cells. It is a very large species, its branches often amounting to many hundreds, and presenting on their two surfaces some hundred square inches of cells. It has a strong and pleasant odour of violets, which it retains for some time after being taken from the sea, and it is probably the species which the inhabitants of Iceland are said to chew as a substitute for tobacco. The branches have a thick, opaque, and coarse appearance, generally a yellowish-grey colour, and a rough surface covered with minute reverted spines; they are variously subdivided, but most frequently present a broad palmate form, terminated by numerous rounded and expanded digitations. The sides of the stems and lower branches do not present the thickened, opaque, and compact margins we find in the *F. truncata* and *F. carbacea*, which are much more delicate species. The tips of the branches are thin, soft, and transparent, as in other branched species, and as in the anterior margin of sessile species, from their containing little calcareous matter, and from the polypi in that situation being young, colourless, and translucent. The boundaries of the cells on the opposite plains do not coincide, nor have they any determinate relation to each other in their position. The broad rounded extremity and the aperture of the cells are always above, the contracted and flat base always below. The cells are arranged on each surface, as in the *F. carbacea*; the opaque sides of the cells form continuous ramified lines from the base to the apex of the branches; and the first cell of a new series in the middle of the branch is always smaller than the cells which surround it, being confined to a small angular space, formed by the bifurcation of the opaque lateral wall of a perfect cell. The tips of the branches are never bounded by a smooth continuous line, as we observe them in the *F. carbacea* and *F. truncata*, but are terminated by the round bulbous ex-

tremities of the last two rows of cells; this remarkable difference is observable by the aid of a common lens.

The cells are shorter and proportionally broader than in the *F. carbacea*, being about the sixth of a line in length, and a little more than half as much in breadth. By tearing the two plains of cells asunder, we render them nearly as transparent as in the *F. carbacea*, and can distinctly perceive the structure of the parts within. The aperture of the cells is formed by a semicircular lid, convex externally and concave internally, which folds down when the polypus is about to advance from the cell. The opening of this lid in the *F. truncata*, where it is very long, appears through the microscope like the opening of a snake's jaws, and the organs by which this motion is effected are not perceptible. The lid of the cells opens and shuts in *flustræ*, without the slightest perceptible synchronous motion of the polypi. We sometimes observe parts, in other calcareous zoophytes, possessing distinct power of motion, though apparently unconnected with the body of the polypi; thus in the *Cellaria avicularia*, Lam. whose polypi have the same structure, and the same connection with the cells as in *flustræ*, I have observed in living specimens a constant motion of flexion and extension in the remarkable testaceous processes shaped like a bird's head, and attached by peduncles to the outside of all the cells. These processes or organs are likewise provided with lateral folds, like the valves of a shell, which have a distinct and regular motion corresponding with the flexion and extension of the entire process. The aperture of each cell of the *F. foliacea*, is defended by four projecting spines, which arise from the calcareous margin of the cell. There are two spines on each side of the aperture, and the upper two are more than twice the length of the lower pair, and slightly curved upwards. When we look transversely on the surface of a branch, the spines appear to be arranged in very regular transverse curved rows, and when we observe the surface longitudinally, they appear to be arranged in very regular longitudinal straight lines. The spines are calcareous, tubular, cylindrical, shut at their extremity, and appear obviously destined to protect the expanded polypi. The two pairs of spines belonging to each cell are placed only on the upper half of the cell, although, from the contiguity of the cells, the lower half of each is likewise defended by the spines of the adjacent cells,

so that they serve also to protract the polypi when in a retracted state. No projecting spines of this kind are found in the *F. carbacea*, and they form the most obvious character of the *F. foliacea*. The bundles of minute spicula pointing horizontally inwards from the margins of the cells in the *F. carbacea* are not present, nor apparently required in this species. By the aid of the microscope, we perceive the same vascular appearance of the thin membranous covering of the cells as in the *F. carbacea*, the same dark round spot in the center of those cells which have lost their polypi, the same imperfectly formed empty cells along the margins of the branches, and similar rudimentary polypi in the last two or three rows of cells at the free extremities of the branches.

The polypi of the *F. foliacea* are about twice as long as the cells, have their body coiled up in a spiral turn, and bifurcated near its lower extremity, and they have the same attachment by bundles of soft loose fibres to the aperture and base of the cells, as in the species already described. They have only fourteen tentacula, sometimes thirteen, which are very long, slender, and ciliated on their two lateral margins. The expanded tentacula form a bell-shaped cavity, into which there is a constant current of water, produced by the incessant rapid vibration of the *cilia*, and in the center of this cavity is the circular prominent retractile mouth of the polypus. The tentacula remain in this expanded and regular form, when the polypi are found hanging dead from their cells; and the same is observed in many other zoophytes, which enables us to observe their number and form with more ease through the microscope. The head of the polypus is small, the body comparatively strong, the continuation of the body below the bifurcation very thick, conical, and tapering to its posterior termination, the globular appendix of the body, and its tubular cervix, are smaller than in the *F. carbacea*, and the same opaque matter is found in the cavity of the globular sac. A distinct and constant revolution of particles is seen in the whole of the tube leading from the body of the polypus into the round sac, as if produced by *cilia* placed within; there is no pulsation or contraction of the part, nor can we perceive any fluid passing from that cavity into the vessels so extensively ramified on the coats of the cells. A similar continued vibratory motion is seen within the mouth in most polypi, which is

undoubtedly produced by ciliæ in that situation ; these minute processes appear to be the only active organs in the circulation of the fluids in zoophytes. The body of the polypus has the usual red colour, while the head and arms are nearly colourless. The long cylindrical and curved body of the polypus is tubular to its posterior termination, which is shut ; and we can sometimes perceive a small bolus of food moving to and fro in the conical part of the body below the bifurcation. The globular sac in this species does not appear to be connected with the formation of the ovum, nor with the regeneration of new polypi in the old cells.

The ova of this species of *flustra* begin to appear early in autumn, and continue to be generated in the cells during the whole winter ; those of the *F. carbacea* make their appearance later in the season ; and I have elsewhere shewn, that, in other zoophytes, different species of the same genus vary much in their season of generation, though residing together on the same rock. The ova first make their appearance at the narrow base of the cells as very small, pale-red, gelatinous spheres, and the polypi of such cells are generally removed, and only a small round dark brown spot is seen in their stead, in the center of the cells. There is but one ovum in each cell, as in other *flustræ* and calcareous *cellariæ* ; and, as it enlarges in size, it advances higher in the cell, till, in its mature state, it occupies the broad upper part of the cell. When the mature ovum is found at the summit of the cell, we observe a distinct wide helmet-shaped capsule surrounding it, and separating it from the cavity of the cell. By examining the ovum within this capsule, with the microscope, we perceive its ciliæ in rapid motion ; and I have frequently observed the ovum, in this situation, contract itself in different directions, shrink back in its capsule, and exhibit other signs of irritability before its final escape. The helmet-shaped capsule of the ovum is open at the top, and connected with the aperture of the cell, so that the ovum readily escapes, by contracting its body and moving its ciliæ. On escaping from the cell, the ovum glides to and fro by the action of its ciliæ, and, after fixing, it is converted into a single complete cell, from which new cells shoot forward. Polypi make their appearance in shut sacs, at the bottom of the new cells, when they are sufficiently formed to protect them. When the ovum has escaped from the cell, the dark round spot in the center of the cell enlarges, and a new po-

lypus shoots out from that point, so that, at this season, we observe young polypi, in every situation, on the branches, the whole of the old cells are thus never found entirely deserted, the same cells may repeatedly produce ova and polypi, and the whole zoophyte retain its energy for several seasons.

Account of an Aurora Borealis, observed at Edinburgh 16th January 1827; with some particulars of another, of a preceding year. With a Plate. By D. BLACKADER, Esq. Communicated by the Author.

ABOUT 9 o'clock, P. M., evening fine, brilliant moonshine, a beautiful white, opaque, drapery of cloud, extending from the zenith to within about 15° of the NW. horizon. The wind had for some days been boisterous and variable, and had veered, in the morning, from NW. to NE.; but the air was now calm and serene. In the course of a few minutes the cloudy tissue had entirely disappeared, and a brilliant aurora was exhibited, in rapid change of feature, and distinguished by unusual proximity. Horizontal cloudy vapours, of great tenuity, repeatedly accompanied its more brilliant evolutions, seeming to support its columns; appearing and vanishing with the more vivid coruscations. Thereafter, the aurora became extended, to right and left, forming the segment of a large circle, although not exceeding in altitude more than 15° , and, at either extremity, vanishing, like the higher strata of clouds, in the blue expanse. This arch may be conceived of by means of the sketch, Plate IV. No. 1.; whereof the landscape includes an angle of about 90° , having its centre in the magnetic meridian; near to which a principal star is seen, at that hour. The lower edge of this arch was always above that star. Subsequently, a second arch was formed in front thereof.

On the right extremity, the arch always presented a broken or interrupted line, with recurrence of separate masses of luminous spears, of a brilliant bluish-white lustre; a golden tint, and burnished lustre, distinguished the continuous arch of the central portion, which, towards the left, became coppery. The second, or front line, was uncommonly distinct, and much nearer than the one first formed. Other figures, afterwards