completed, which the earth required to the full development of its own constitution; that, after it began, it proceeded by successive steps from the less to the more perfect formations, ending with man as the head of the whole.

Observations on the Structure and Functions of the Sponge. By R. E. Grant, M. D., F. R. S. E., F. L. S., M. W. S., Honorary Member of the Northern Institution, &c. Communicated by the Author. Concluded from the preceding Volume, p. 351. (With a Plate.)

The silicious and calcareous spicula above described are grouped into strong fasciculi, which are disposed around the internal canals of the sponge, in the order best calculated to defend these passages from compression, and from the entrance of extraneous bodies, and likewise to form between the canals certain interstitial spaces for the development and exit of the ova. Like the hard parts composing the skeleton in other animals, these earthy spicula are maintained in their relative situations by a tough ligamentous matter, distinct from the other soft parts of the sponge. In the horny species, however, where the axis is composed of cylindrical tubular horny fibres, ramified and continuous throughout the whole body, this connecting cartilaginous matter appears to be unnecessary, and, from the examination of dried specimens, it appears to be altogether wanting. The examination of the living properties of the axis in the horny species forms a subject of curious and interesting inquiry, which must be left to those who have opportunities of observing them alive in warmer latitudes, as they do not seem to inhabit the British shores. The dried filaments of the *S. fistularis*, Lam. when viewed through a powerful microscope, appear to consist of one continuous ramified tube, whose central cavity (Pl. II. Fig. 19. *b*) is entirely filled with a dark opaque granular matter, which does not consist of spicula, while the sides of the tube *(a)* are transparent and amber coloured like common cat gut. In the *S. officinalis*, where the filaments are much finer, the sides of the tube (Fig. 20. *a)* have the same colour and homogeneous appearance, but the central cavity *(b)* appears empty. Mr Ellis states, that, in the branched species, the central cavities of the horny filaments are filled with a soft white matter, and that they terminate by distinct apertures on the surface of the body; and he considered these cavities as undoubtedly the habitations of animals of a particular kind, (Hist. des Cor. p. 94). The confirmation of this opinion, by accurate experiments, would establish a very striking distinction between these elastic species and the more friable earthy sponges of our own shores, and would point out a remarkable approximation in these highly organised species to the polypiferous axis of tubulariæ, sertulariæ, and other keratophytes. In all the calcareous sponges which I have hitherto examined, we invariably find triradiate spicula, which are completely enveloped in the *connecting matter*, and are employed in forming the bounding fasciculi of the pores. Besides these complicated spicula, we frequently find a second and simpler form of spiculum, one extremity only of which is immersed in the connecting matter, while the other end, projecting free from the surface, defends the entrance of the pores and orifices. Thus, in the *S. compressa* (Fig. 23.), the bounding triradiate spicula (Fig. 11.), of various sizes, are found enveloped in the tough connecting matter around the pores, the defending clavate spicula (Fig. 12.) have their straight tapering portion immersed in the connecting matter, while their curved extremity hangs free over the entrance of the pores. In the *S. coronata* the connecting matter seems to cover entirely the bounding triradiate spicula (Fig. 17.); and only the thick obtuse extremity of the needle-shaped defending spiculum (Fig. 18.) is immersed in it, while the tapering pointed end hangs free over the pores and fecal orifice. I have never observed a combination of calcareous and silicious spicula in the same sponge, nor any kind of spiculum in the horny species. Two distinct forms of spicula are very seldom observed in silicious sponges, though they are frequent in the calcareous species. In the *Spongia ventilabrum*, Lin., besides the long waved silicious filament (Fig. 5.), we observe a distinct needle-shaped spiculum obtuse at one end, and tapered to a point at the other, (similar to Fig. 18). In the *S. pilosa*, Mont., besides the long straight fusiform spiculum, we observe a shorter curved spiculum, of equal thickness throughout, and rather obtusely pointed at both ends, like that of the

Spongilla friabilis (Fig. 1.), but larger. In general, however, the only difference observed among the silicious spicula of the same individual is a great variety in their size. Donati not only observed that the hard spicula of the *Tethya sphœrica* differed remarkably in size, but likewise, that they were bound together by a peculiar fleshy or tendinous matter, (Mar. Adr., p. 62). In the *S. coalita*, besides the slender curved fusiform spiculum (Fig. 2.), we observe a long thick spiculum of the same form, which extends along the sides of two or three successive pores, and contributes much to their strength in a species peculiarly liable to have the diameter of these passages disturbed from the flexibility of its branches, and their erect position at the bottom of the sea.

At the approach of death, and during putrefaction, the soft gelatinous or cellular matter of the *S. panicea* escapes plentifully from every opening of the body, and drops down like the ropy transparent colourless matter of an egg, without loosening, in the slightest degree, the connecting matter of the spicula, or altering perceptibly the form of the skeleton. When we extract, by strong pressure, the cellular matter from the *S. coalita*, *S. tomentosa*, &c. we obtain a very tough leathery substance, composed of spicula firmly bound together by the cartilaginous matter, and retaining the original colour and form of the sponge. By repeatedly and strongly agitating a thin portion of the recent *S. papillaris* in fresh water, and then examining it under a powerful microscope, we find that the cellular matter has been entirely washed away, and the spicula are left imbedded in a transparent homogeneous tough matter, which retains its original colour and form unaltered. This *connecting matter* tears like a piece of cartilage, emits a fishy odour when burnt, dissolves without effervescence in nitric acid, contracts much, and acquires an amber colour by drying, and becomes very brittle in the dried state, probably alone from the earthy spicula it contains. There seems, therefore, to be a distinct matter in the earthy sponges for connecting, and probably secreting, the spicula of their skeleton. The dried preparations of this animal, preserved in museums, owe their form and stability to this tendinous connecting substance, and, from its close resemblance in the dried state to the amber coloured filaments of horny species, it is probable, that, by removing the spicula, we might obtain from the earthy sponges of our own coasts the advantages for economical use derived from the elastic species of tropical seas. The soft gelatinous matter mentioned above, as escaping abundantly from the broken *S. panicea*, is met with in greater or less quantity in all the other species which have been examined. Cavolini observed it to be very abundant and consistent in the *S. officinalis* and *S. carnosa*. Schweigger observed it to be most abundant in the sponges of the Mediterranean in autumn. Vio and Olivi considered it as a distinct matter from the other soft parts of the sponge; and Schweigger found it to consist almost entirely of minute granules, with a little transparent moisture. It has an unctuous feel, emits a fishy odour when burnt, leaves a thin film or membrane when evaporated, and appears to the naked eye transparent, colourless, and homogeneous, like the colourless part of an egg. But, when a drop of it is examined on a plate of glass under the microscope, it appears entirely composed of very minute, transparent, spherical or ovate granules, like monades, with some moisture. These monade-like bodies, nearly all of the same size and form, resemble the pellucid granules or vesicles, which Trembly has represented as composing the whole texture of the hydræ, or the soft granular matter we observe in the stems of living sertulariæ, and, indeed, most of the fleshy parts of organised bodies appear to be composed of similar pellucid granular or monade-like bodies in different states of aggregation. This soft substance, which might be termed the *parenchymatous matter* of the sponge, to distinguish it from the tough connecting matter of the spicula, is found in all parts of the body, but is chiefly contained in the intermediate spaces between the parietes of the internal canals, and it is more abundant at the time when the ova first make their appearance. The tough glistening substance which lines the internal canals, and passes over the surface, between the pores, is the most highly organized part of the animal. That of the canals resists repeated strong agitation in fresh water, and appears through the microscope a very consistent homogeneous jelly, with a rough granulated internal surface. The roughness sometimes assumes a lineal appearance, exhibiting the rudiments of fibres, and the transparent granules which project considerably from its surface, become more rare near the fecal orifices. There is an apparatus at the entrance of the pores, of a nature very different from any of the parts already described, and which throws much light on the functions of these openings. When we cut a thin layer from the surface of the *S. papillaris* (fig. 21.), and look down through one of its pores with the reflecting microscope, we perceive a very delicate net-work of gelatinous threads (fig. 25, *c*) thrown over the entrance of the pore. This piece of structure is so fine as to be perfectly invisible to the naked eye, and is always effaced in dried specimens. It is present in every pore of the living animal, and consists of several broad filaments of a soft transparent, colourless, and perfectly homogeneous substance, which pass directly inwards from the bounding fasciculi, (fig. 25, *a b*) or gelatinous margins of the pores, to be connected with one or more central meshes, formed of the same threads, and lying in the same plane. This gelatinous net-work, consisting generally of six or seven meshes, lies always beneath the defending fasciculi (fig. 24. *b*) in the species where these occur. And, while it is admirably protected by the depending spicula of the pores, as in the *S. panicea*, where these spicula spread over it like the rays of a fan, it serves to guard still more completely the interior of these passages from particles of sand or small floating animalcules. By making deeper sections, we sometimes observe one or more net-works of a simpler structure (fig. 26. *c*), but of the same nature, lying beneath the first. None of the projecting granules, which line the whole internal surface of the canals, and compose the parenchymatous matter, are seen on any part of these net-works, and their position, regularity, and constant appearance, sufficiently point out their function, and show, independently of the surrounding frame-work, and the currents passing constantly in, that the pores are not the open cells of polypi, nor accidental perforations, made by worms or animalcules in a pulpy substance. When we examine carefully the base of sessile species of sponge, we observe, that the part which forms the connecting medium between their body and the rock on which they spread, is a tough consistent gelatinous substance (fig. 21. *h*), similar to that which lines the canals, and passes over the surface between the pores; it insinuates itself into all the inequalities of the surface to which it is attached, and is the part we observe to advance first during the spreading of the ovum, (fig. 29. *b*). It is a very remarkable circumstance, that Aristotle is almost the only writer who has described this part of the anatomy of the sponge. He observes, that they do not adhere by a continuous surface; that they have some intermediate empty canals; that they are fixed only at particular parts to the rocks, and have a kind of membrane spread out under their base (Lib. v. cap. 16.) He has accurately distinguished and described the pores and fecal orifices, and was as well acquainted with their functions as Ellis or Lamarck. He says, we observe on the upper surface of the sponge minute pores (ποροι) placed close to each other, and almost imperceptible, and a few, about four or five, wide orifices (φανεροι), through which the animal is supposed to take in nourishment."—*Ibid.*

The organs which we know to cause the currents in other zoophytes, and in infusoria, are very small, short, almost imperceptible processes, termed ciliæ, disposed around the mouth, or on the tentacula. They are kept in a state of very rapid vibration during the expanded state of the animals, for the purposes of nourishment, respiration, or progressive motion. The highest orders of aquatic animals produce currents in the water, by the contraction and relaxation of various muscular parts of their bodies; and the most perfect inhabitants of the dry land produce similar currents in the air to oxidate their blood. We are not yet acquainted with any zoophyte capable of producing these currents, by contracting and dilating its axis; and I have already shewn, that the currents of the sponge are not produced by any contraction or dilatation of the mass of its body, or of the pores, canals, or orifices. No naturalist has ever discovered polypi in the sponge; and, as I have used every effort in vain to detect them with a microscope, magnifying nearly a hundred times, it is very probable that no such organs exist. If they be present and indistinguishable by such aid, they must be at least a hundred times finer than a filament of silk, and the ciliæ of the tentacula of such polypi would bear no proportion to the velocity and volume of the currents already described. I have stated above, that the currents can be distinguished by the naked eye passing into the open pores of the *S. panicea*, and they are readily seen through the microscope passing into the pores in most of the other species. I was therefore led to suspect that the currents are not caused by polypi on the surface, but by ciliæ, or some similar apparatus, placed around the entrance of the pores, or on the margins of the gelatinous net-works, or on the whole surface of the internal canals. I first placed a thin layer from the surface of the *S. papillaris*, in a watch-glass with sea water under the microscope, and, on looking through its pores, I perceived the floating particles driven with impetuosity through these openings, they floated with a gentle motion to the margin of the pores, rushed through with a greatly increased velocity, often striking on the gelatinous net-works, and again relented their course when they had passed through the openings. The motions were exactly such as we would expect to be produced by ciliæ, disposed round the inside of the pores; but the most intense observation, with high magnifying powers, did not render ciliæ visible on this or any other species which I examined. I now took deeper sections from the substance of a great variety of living sponges, after removing their surface, and on examining them in the same manner, under a powerful microscope, I found that, wherever a portion of an internal canal presented itself, there was a distinct and rapid current through it, but the moving organs were as little distinguishable on these, as on the margins or net-works of the pores. On looking with the microscope through the pores of a detached portion of the *S. compressa*, (fig. 23. *d*,) I have sometimes observed a confused motion among the granular bodies lining their sides, and have even seen these monade-like bodies in groups staggering to and fro, when they had fallen separate to the bottom of the watch glass. But, although every known analogy would lead us to believe that these motions and the currents are produced by ciliæ, I have never been able, by any artifice, or by the highest magnifying powers, to bring them distinctly into view in any species of sponge.

What relates to the formation, expulsion, and development of the ova, I shall exemplify chiefly by what I have observed during three successive winters in the *S. panicea*, adding at the same time such peculiarities as I have remarked in other species. By dividing this memoir into parts, and thus protracting its publication, I have been enabled to vary and repeat my experiments; to observe the animal at all seasons of the year; and to confirm my observations, by various continental authorities which were unknown to me when my experiments were first read before the Wernerian Society. During the months of October and November, we observe a remarkable change taking place in the internal texture of the *S. panicea*, the parts which in summer were transparent, and nearly colourless, have now become every where studded with opaque yellow spots visible to the naked eye, and without any definite form, size, or distribution, excepting that they are most abundant in the deeper parts of the sponge, and are seldom observable at the surface. The parenchymatous matter seems likewise to be more abundant throughout the whole body. By examining thin sections with the microscope at this period, we find that the bright yellow spots consist of groups of very minute irregular-shaped gelatinous granules, which lie imbedded in the parenchymatous matter, and are contained in certain recesses formed between the parietes of the internal canals, (fig. 26, *b*.) These yellow granules are the rudiments of the ova, and when they are first perceptible by the aid of the microscope, they consist only of a small round compact group of the same monade-like bodies which compose the parenchymatous matter; they have no cell or capsule, and appear to enlarge by the mere juxtaposition of the monade-like bodies around them. As they enlarge in size they become oval shaped, and at length in their mature state they acquire a regular ovate form. In about two months after their first appearance, the ova are nearly a fifth of a line in length, and half as much in breadth, and the greater number of them have acquired the same ovate form and bright yellow colour. Their form is now quite distinguishable by the naked eye, both when floating detached in water, (above fig. 26,), and when lying in groups in the substance of the animal, (fig. 21. *f*, *f*.). Before they have attained this perfect ovate form, they are not washed out from broken sponge, by violently shaking it in water, but now they readily fall out from broken portions, without any agitation, and we generally find a great number of them floating in the water in which specimens of this sponge have been placed in the months of December, January, February, and March. If we watch the fecal orifices with some attention during any of these months we observe many of the ova pass out spontaneously along with the currents and feculent matter, (fig. 21. *e.*), and when they have been discharged by the fecal orifices, or have fallen out from broken portions of the sponge, they do not sink to the bottom of the water by their own gravity, like every other substance composing the body of the animal, but continue floating and drifted about by the currents. The most remarkable appearance exhibited by these ova, is their continuing to swim about by their own spontaneous motions, for two or three days after their detachment from the parent, when they are placed separately in vessels of sea water, at perfect rest. During their progressive motions, they always carry their rounded broad extremity forward, and when we examine them under a powerful microscope, we perceive that these motions are produced by the rapid vibration of ciliæ, which completely cover the anterior two-thirds of their surface, (fig. 28. *a.* to *c.*). I have not perceived any ciliæ on the tapering posterior third of their body (fig. 28. *c.* to *b*), which has a whiter and more pellucid appearance even to the naked eye, than the ciliated anterior part. By examining the sponge carefully with the microscope, we are surprised to find that many of the mature ova are now hanging by their tapering extremity from the parietes of the internal canals, (fig. 26. *d*, and fig. 21. *g.*), either by having advanced themselves into the canals, or by opening new passages for themselves, by the motions of their ciliæ. While in this fixed situation their ciliæ are always in a state of very rapid vibration, which has a tendency to tear them from the sides of the canals, and when their connection is once destroyed, they are driven headlong by the currents through the fecal orifices (fig. 21.) The singular motions and structure of the detached ova, are best observed by placing a few of them together in a small drop of sea water, on a plate of glass under a powerful microscope. They have all the same size, the same regular ovate form (fig. 28), and the same bright yellow colour by reflected light; but by transmitted light they have an amber colour, appear much less translucent in the central parts than towards the sides, and have a rough granulated surface. Their ciliæ are longest, and exhibit the most distinct motions, on the anterior part (fig. 28. *a.*), and become gradually shorter and more imperceptible as we approach the tapering extremity, (fig. 28. *c*, *b*.), which has a granulated translucent appearance, but exhibits no ciliæ. The part of the surface on which the ciliæ immediately rest is more transparent than the other parts, and appears like a thin gelatinous covering spread over the other darker parts within. The ciliæ are very minute transparent filaments, broadest at their base, and tapering to invisible points at their free extremities; they have no perceptible order of succession in their motions, nor are they synchronous, but they strike the water by constantly and rapidly extending and inflecting themselves; and the result of these motions is, that the ova either impel the water backwards from their anterior towards their tapering end, or they advance through the fluid, carrying their broad ciliated extremity forward. We sometimes observe them standing erect on their tapering extremity, and revolving quickly round their long axis. This is particularly remarked, after they have been swimming about for a day or two, and are about to fix themselves on the surface of the glass. When viewed from above in this erect position, they appear perfectly circular, (fig. 27.) with a translucent margin, and a complete circular zone of moving ciliæ, (fig. 27. *b*.); and when they have continued to move their ciliæ for some time in this erect position in a watch-glass, they clear away all loose particles of matter from beneath their base, and accumulate a perceptible zone of loose sediment (fig. 27. *c*.) at a little distance from their circumference (fig. 27. *b*.). The incessant slow gliding motions of these ova to and fro through the water, are not like those of animalcules. They appear to have no definite object, and are not performed by starts, like the zig-zag motions of animalcules in search of prey; yet the ova appear to have a consciousness of impressions made on them. When they strike against each other, or against any object in their course, they retard a little the motions of their ciliæ, glide for a few seconds round the spot, and then renew the action of their ciliæ, and proceed in their smooth gliding course. They frequently collect in large quantities at the surface of the water round the margin of the vessel, in which the broken sponge is laid; and I have observed them particularly accumulate on that part of the glass jars which was shaded most from the light, by the body of the parent. About a thousand ova are contained in every cubic inch of the *S. panicea*, and a specimen of moderate size may be computed to discharge at least ten thousand ova every season. The smaller species are much more prolific. On cutting an ovum transversely through the middle, the ciliæ on its anterior half continued in motion for twenty-four hours. On tearing an ovum to pieces with two needles on a plate of glass, we perceive, by the aid of the microscope, about twenty rudimentary spicula occupying its central opaque part, and having the same form with those of the parent. The ovum does not show any power of changing its form, during its most active state, which the ova of some higher zoophytes distinctly exhibit. During the months above mentioned, every specimen of the *panicea* is found crowded with ova; some presenting them in a more advanced state than others, and the same specimen presents them in every stage of maturity.

In about two or three days after the ova of the *S. panicea* have separated from the body of the parent, we observe them beginning to fix themselves on the sides and bottom of the vessel, and some of them are found spread out like a thin circular membrane on the surface of the water. Those which have fixed on the sides of the vessel, have a more regular circular outline than those on the surface of the water, which have often a torn appearance, with holes of different sizes through them; but in all those which have thus fixed and spread out like a thin transparent film, we can very distinctly perceive, with a single lens, numerous spicula, disposed without any apparent order throughout their central parts. On immersing several watch-glasses in a basin of sea-water, containing many specimens of the *S. panicea* in the act of discharging their ova, I found, after a few days, that most of the ova had fixed on the outside of the watch-glasses, so as to have their pores and orifices, when fully grown, vertically downwards, and almost none were in the concavities of the watch-glasses, where I wished to collect them. It is easy, however, to cause them to fix and grow in the concavities of watch-glasses, by placing them there near the natural time of their fixing, when the ova exhibit much less inclination to swim about; and the progress of their development is most conveniently watched when they are caused to grow in that situation. When we examine the ova through the microscope, while in the act of fixing on the surface of the glass, we find that they are always so placed, that some part of their white translucent base (fig. 28. *c*, *b*.), is in contact with the glass ; and this part has not only the power of adhering firmly to the surface, but that of spreading itself outwards, so as to extend the whole ovum into a thin transparent convex circular film. During the expanding of the base, the ciliæ are still observed in rapid motion on the upper part, and propelling particles of matter to a distance. They soon, however, become languid, and, in the course of a few hours, they cease to move, first at a particular part, and then gradually round the whole circumference. When first completely expanded, the whole ovum appears to consist of granular monade-like bodies, with a few spicula interspersed through the central parts, (fig. 29. part within *d*.). But within the space of twenty-four hours, a beautiful transparent, colourless, and perfectly homogeneous margin, has spread out round the whole ovum (fig. 29. *b*.), which continues to surround it during its future growth. And although all visible ciliæ have ceased to move, we still perceive a cleared space around the ovum, and a halo of accumulated sediment, (fig. 29. *c*.), at a little distance from the margin. The spicula, which at first were small, confined to the central part, and not exceeding twenty in number, now become much more numerous and larger, and some of them even make their appearance in the thin homogeneous margin (fig. 29. *b*.). The spicula make their appearance completely formed, and do not seem afterwards to increase their dimensions. I have never observed a spiculum in the act of making its appearance, but have thought that I perceived a lineal arrangement of the monade-like bodies in the interior of the ovum, where the spiculum afterwards started into being. When two ova, in the course of their spreading on the surface of a watch-glass, come into contact with each other, their clear homogeneous margins unite without the least interruption, they thicken and produce spicula : in a few days we can detect no line of distinction between them, and they continue to grow as one ovum. Cavolini long since observed, that, when two adult specimens of the *S. rubens*, Pall. growing on the side of an earthen vessel, came into contact with each other, they grew together and formed an inseparable union, (Abhand. p. 126.) In a few weeks after an ovum has fixed, the spicula assume the appearance of fasciculi ; at particular places towards the centre they present circular arrangements, and distinct openings are at length perceptible, by the aid of a microscope at these inclosed places. The ova spread and enlarge in every direction, they become more compact in texture, more opaque and convex; and, before they exceed a line in diameter, they present through the microscope a marked resemblance to the parent sponge.

The ova make their appearance at very different seasons, in different species of sponge, and the same species very probably, varies its time of generating, according to its latitude. Olivi, Vio, and Schweigger, observed these yellow ovate bodies only in autumn in the sponges which they examined in the Mediterranean, (Schweigger's Beob. auf R. R. p. 90). From the season of their appearance, Olivi considered these bodies as grains, while Vio and Schweigger considered them as ova, from their believing the sponge to be an animal. The latter authors observed, that they were distributed, without any apparent order, through the gelatinous matter, and that they were of a somewhat different colour from that matter, and more consistent. Schweigger considered them as beings formed out of that matter, and capable of independent existence,—an opinion which happily accords with the experiments above detailed. In the *S. papillaris, S. cristata*, and *S. tomentosa*, on Leith rocks, the ova do not make their appearance till spring. They are present in April, May, and June; and they exhibit the same mode of distribution through the deeper parts of the animal, (fig. 21. *f, f.*), the same ovate form, granular or vesicular texture, ciliated anterior surface, mode of expulsion, and spontaneous motions, as in the *S. panicea*. They have a darker yellow colour, and a more lengthened posterior extremity, than those of the *S. panicea*, and we can scarcely detect the rudiments of spicula in them, at the time of their expulsion. It is somewhat remarkable, that, in the portions of these species, which we frequently find of a deep sea-green colour, the ova have exactly the same yellow colour, as in specimens which present their more common yellow hue. I have repeatedly performed, during two successive summers, the same experiments on these ova as those above detailed, and with the same results. From the manner in which these ovate bodies are formed in the parenchymatous substance of the sponge, and their changes after expulsion, this animal appears to present a new and singular mode of internal gemmiparous generation. Since these germs, or so-named ova, are evolved within the body of the parent, and are detached without injuring or affecting its general form, this may be considered as a more complicated, or more perfect, kind of generation, than that by spontaneous division, exhibited by animalcules, where the form of the parent's body suffers materially during the process, and half of its substance is removed. As the ova of the sponge, however, are not fully formed individuals at the time of their separation, but require to undergo a further change to bring them to the fixed and perfect state of the parent, this mode of generation is less perfect than the true external gemmiparous generation of the hydra, where the new individual falls off from the body of the parent in a state of perfect maturity. Many other zoophytes exhibit the same kind of internal gemmiparous generation by the detachment of imperfectly formed portions of their soft substance; their ova require to undergo the same metamorphosis to bring them to the perfect state, and they exhibit the same singular spontaneous motions during the intermediate state between the time of their forming a part of the parent's body, and that of their existence as new individuals. Mr Ellis observed similar spontaneous motions in the ova of the *Campanularia dichotoma*, Cavolini in those of the *Gorgonia verrucosa* and *Caryophyllia calycularis*, and I have observed them in those of the *Plumularia falcata* (See Ed. New Phil. Journ. vol. i. p. 155). The power of spontaneous motion is not given in vain to these minute portions of gelatinous matter on which the propagation of the species depends. As the fecal orifices open into the general cavity in such cup-like sponges as the *S. ventilabrum* and *S. patera*, which sometimes appear to grow erect in the still recesses of the deep, the spontaneous motions of the ova in these, and, in all erect tubular species, will aid their escape, and prevent them from destroying the parent, by a parasitic growth in the interior. The power of spontaneous motion will prevent the ova of such species as the *S. oculata*, *S. panicea*, *S. palmata*, and *S. compressa*, which hang vertically from the roofs of caves, from sinking by their gravity to the bottom, where they could not fail to be crushed or buried among the moving sand, and will enable them to seek and to take that vertical position which seems necessary to their future development; and, by this locomotive power, produced by the vibrations of the ciliæ, the ova are suspended for a longer period at the mercy of the waves, the tides, and the streams of the ocean, by which the species are gradually spread over the globe. Thus the *S. communis*, *S. lacinulosa*, *S. usitatissima*, and other horny species, which seem to be confined to warm climates, and abound in the Red Sea and the Indian ocean, appear to have been gradually wafted by the Gulf Stream from the shores of the east to corresponding latitudes of the new world. The *S. fulva*, *S. fistularis* and fine varieties of the *S. officinalis*, Pall. are among the horny species which abound on the tropical shores of America, and their elastic filaments form a beautiful transition to the cartilaginous threads which wind round the cells of Alcyonia. All the known calcareous sponges are inhabitants of the British coasts; the delicate and minute *S. compressa* has been seen on the shores of Greenland, Shetland, Scotland and England, and I have found it along with the *S. nivea* abundant and extensively distributed over the Western Islands. The *S. botryoides*, *S. nivea*, and *S. compressa*, are calcarious species, inhabiting the Frith of Forth. An immense number of silicious species inhabit our northern latitudes; and from their peculiar habits, their simple structure, and their tenacity of life, they are probably the animals which exist nearest to the poles. The *S. coalita*, *S. oculata*, *S. dichotoma*, *S. prolifera*, *S. palmata*, *S. suberica*, *S. papillaris*, *S. panicea*, *S. cristata*, *S. tomentosa*, and *S. cinerea*, Gr., (fig. 3.) are found in the Frith of Forth. The *S. papillaris* and *S. tomentosa* I have found common on the coasts of Britain, Ireland, and the Western Islands; and I have observed the *S. panicea* roofing the excavated basaltic cliffs of the island of Staffa. The *S. sanguinea*, Gr., (fig. 9.) a remarkable blood-red sessile species, I have found growing, like the *S. panicea*, on the under surface of the sea-beaten rocks of Islay, Staffa, Iona, and, along with the *S. nivea*, at the entrance of the spar caves on the shores of Skye. The *S. tomentosa* is said to occur on the shores of Europe, North America, Africa and India (Lamouroux, Hist. des Polyp. p. 30.); but I believe it has not been authentically shewn that the same silicious species occur in the corresponding latitudes of the two hemispheres; indeed the geographical distribution of the species cannot be satisfactorily ascertained till their characters are better described and defined. This animal, however, seems eminently calculated for an extensive distribution, from the remarkable simplicity of its structure, and the few elements required for its subsistence. Its inertness, its soft gelatinous structure, its want of organs for seizing prey, the incessant currents through its body, and the growth of its ova, when nourished only with sea-water, shew that it subsists either on the elements of that fluid, or on the minute particles of organic matter suspended in it. Its canals present the first rudiments of an internal stomach; by these simple organs it extracts a mass of gelatinous matter from the waters of the ocean, and organises it for the digestive organs of animals higher in the scale. Its interior affords a domicil and a magazine of food for myriads of minute marine animals. It extracts silicious matter from the ocean, and precipitates it in regular and beautiful crystalline forms. It precipitates, in the form of an insoluble carbonate, the calcareous matter continually poured by rivers into the bed of the ocean in a soluble state; it thus assists in purifying the vast abyss of a corrosive ingredient, and prepares it for the maintenance of the various tribes of vertebral inhabitants that people its boundless expanse. And it has probably aided in the formation of silicious and calcareous rocks.

I have now given a brief outline of the natural history of the Sponge as a genus, and stated the laws which regulate its external form, in so far as I have been able to observe the living characters and habits of the species in the Frith of Forth. I have endeavoured to trace to their sources the discoveries which have been successively made in its structure and economy, and have shewn, that the true nature of this singular being, and the uses of all its parts, were as well known to the ancient Greeks as to the naturalists of modern Europe,—that the description of it given by Aristotle is more correct and complete than that of Lamarck. I have detailed a series of experiments to determine the uses of the pores, canals and orifices; and have shewn, that the incessant currents through these passages, which are subservient to the nourishment, respiration, and reproduction of the animal, are not produced by the alleged irritability of its axis, nor by the supposed systole and diastole of its apertures, but by certain minute organs disposed over the whole surface of the internal canals. I have described the most striking differences which I have observed in the chemical constitution and microscopical forms of the minute parts composing the skeleton of this animal, in the three great tribes of horny, calcareous, and silicious species, and their beautiful arrangements to maintain the general form of the zoophyte, and to support and defend its soft parts. I have stated the characteristic properties and appearances of the connecting matter of the spicula, the parenchymatous, or general cellular substance of the body, the gelatinous net-works of the pores, and the granular bodies of the internal canals. I have examined the successive changes which the ova undergo from the time of their first appearance in the parenchymatous substance of the parent till their full development, and their expulsion from the fecal orifices, the causes of the singular spontaneous motions they exhibit, from the time of their expulsion till their metamorphosis into fixed inert zoophytes, and the progress of their growth in this fixed state, till they attain the perfect form of the parent. And, lastly, I have stated a few observations on their geographical distribution, and their purposes in the economy of nature. The uses of the central cavities in the horny fibres, and in the earthy spicula, and the different forms of these elementary parts, in all the known species; —the mode in which the animal imbibes nourishment through the parietes of the internal canals, and the chemical changes produced on the fluid by its transmission through these passages;—the particular tribes of infusoria and more perfect animals that infest the different species, and depend on them for subsistence, and the applications of the earthy species of this animal to useful purposes in the arts, are still unknown. No one has yet excited to action any part of the adult animal, and the moving organs of the currents have never been seen. The mode of generation of this animal, and the structure of its soft parts, have yet been examined only in a very few species. The characters and the geological distribution of its organic remains have yet to be investigated, and probably not a tenth part of the existing species have yet been brought to light from their recesses in the depths of the ocean. This animal still affords many curious and interesting subjects of inquiry to those who have leisure and opportunities of examining the more perfect species of tropical seas; and, though probably the simplest of animal organisations, the investigation of its living habits, its structure and vital phenomena, and the distinguishing characters of its innumerable polymorphous species, is peculiarly calculated to illuminate the most obscure part of zoology, to exercise and invigorate our intellectual and physical powers, and to gratify the mind with the discovery of new scenes of infinite wisdom in the economy of Nature.

PLATE II.

Fig. 1. Silicious, double-pointed, curved spiculum of the *Spongilla friabilis.* (See Edin. Phil. Jour. vol. xiv. p. 279.) This and the following 19 figures are magnified 50 times.

Fig. 2. Silicious, fusiform, curved spiculum of the *Spongia papillaris.* (See Edin. New Phil. Jour. vol. i. p. 346). This spiculum occurs in *Spongia tomentosa,* or *urens, S. cristata,* and large in *S. coalita.*

Fig. 3. Silicious, double-pointed, curved, short spiculum of the *Spongia cinerea,* Gr. (See zoological notices at the end of the present Number.) This spiculum occurs half as large in *S. oculata, S. palmata, S. dichotoma, S. prolifera,* and *S. cancellata,* Sowerby.

Fig. 4. Silicious, single-pointed, straight spiculum of the *Spongia panicea.* (See Edin. New Phil. Jour. vol. i. p. 347.) This spiculum occurs slightly curved in the *S. parasitica,* Mont.

Fig. 5. Silicious, long, waved filament, obtuse at both ends, of the *Spongia ventilabrum* (see Edin. New Phil. Jour. vol. i. p. 349.), occurs along with another silicious spiculum, similar to fig. 18.

Fig. 6. Silicious, single-pointed, curved, thick spiculum, with a round head on its obtuse end, of the *Spongia patera.* (See Edin. New Phil. Jour. vol. i. p. 348.)

Fig. 7. Silicious, single-pointed, curved, slender spiculum, with a round head on its obtuse end, of the *Cliona celata.* (See Edin. New Phil. Jour. vol. i. p. 80.)

Fig. 8. Silicious, single-pointed, straight, moniliform spiculum of the *Spongia monile*, Gr. (See Edin. New Phil. Jour. vol. i. p. 348.)

Fig. 9. Silicious, single-pointed, curved, long spiculum of the *Spongia sanguinea*, Gr. (See zoological notices at the end of the present Number.)

Fig. 10. Silicious, curved, short spiculum, obtuse at both ends, of the *Spongia fruticosa*. (See Edin. New Phil. Jour. vol. i. p. 350.) For the *S. hispida* the same form occurs, but more than double this length.

Fig. 11. Calcareous triradiate spiculum of the *Spongia compressa*. (See Edin. New Phil. Jour. vol. i. p. 166.)

Fig. 12. Calcareous, clavate, curved spiculum of the *S. compressa*. (Ibid.)

Fig. 13. Calcareous, straight, very minute spicula of the *S. compressa*. (Ibid.)

Fig. 14. Calcareous, triradiate, large spiculum of the *Spongia nivea*. (Ibid. p. 168.)

Fig. 15. Calcareous, quadriradiate, minute spiculum of the *S. nivea*. (Ibid.)

Fig. 16. Calcareous minute fragments of triradiate spicula of the *S. nivea*. (Ibid.)

Fig. 17. Calcareous triradiate slender spiculum of the *Spongia coronata*. (Ibid. p. 170.)

Fig. 18. Calcareous, single-pointed, slightly curved long spiculum of the *S*, *coronata*. (Ibid.)

Fig. 19. Horny tubular thick fibres of the *Spongia fistularis*. (See Edin. Phil. Jour. vol. xiv. p. 339.) *a*. Amber-coloured horny translucent parietes. *b*. Dark opaque granular matter filling the central cavity.

Fig. 20. Horny tubular thin fibres of the *Spongia communis*. (Ibid.) *a*. Amber-coloured transparent parietes. *b*. Empty central cavity.

Fig. 21. Living *Spongia papillaris* under water, shewing its mode of generation, &c. (See Edin. New Phil. Jour. vol. ii. p. 133.) *a, a,* Minute pores through which the currents enter. *b,* Commencement of the internal canals. *c,* Uniting of the internal canals to form a fecal orifice. *d,* A fecal orifice discharging a current of water with feculent matter. *e,* A fecal orifice discharging two ova and feculent matter with the current. *f, f,* Groups of mature ova. *g,* Ovum passing into a canal. *h,* Gelatinous base connecting this animal to the rocks.

Fig. 22. Living *Spongia oculata,* shewing its currents, mode of generation, &c. *a, a,* Minute pores transmitting water obliquely into the canals. *b, b,* Fecal orifices discharging currents, feculent matter, and ova. *c,* Strong fibrous part of the animal by which it hangs from rocks.

Fig. 23. Living *Spongia compressa,* with a part of its side laid open, to shew the terminations of its canals in the interior of its general cavity. *a,* Expanded base by which it hangs from rocks, fuci, &c. *b,* Compressed terminal opening of its general cavity, by which the currents, ova, and feculent matter, finally escape. *c,* Minute pores by which the water passes obliquely through its parietes. *d,* A part laid open, to shew the fecal orifices terminating in the general cavity of the animal.

Fig. 24. A pore of the *Spongia panicea* highly magnified, to shew (*a*) its bounding fasciculi, and (*b*) a defending fasciculus spread over a gelatinous network.

Fig. 25. A pore of the *Spongia papillaris* highly magnified, to shew (*a*) its bounding fasciculi, (*b*) the part where the bounding fasciculi cross each other to form recesses for the ova, and to which the connecting matter of the spicula was supposed to be confined, and (*c*) the most usual appearance of the gelatinous network of the pores in this species.

Fig. 26. A transverse section of an internal canal of the *Spongia papillaris.* *a,* Its bounding fasciculi, covered with the very minute monade-like bodies composing the parenchymatous matter. *b,* Groups of imperfectly formed ova lying in recesses of the parenchymatous matter. *c,* Simplest form of the gelatinous network found within the canals. *d,* Ova hanging by their tapering extremity to the side of the internal canal, and producing currents by the motions of the ciliæ covering their free surface.

Fig. 27. Highly magnified ovum of the *Spongia panicea,* viewed from above, when about to fix. *a,* Central opaque part occupied by spicula, and covered with ciliæ. *b,* Zone of vibrating ciliæ distinctly seen round the margin. *c,* Zone of accumulated sediment, produced by the ciliæ constantly clearing the space next the ovum.

Fig. 28. Highly magnified ovum of the *Spongia panicea,* viewed laterally, to shew its entire ovate form. *a,* Ciliæ, longest on the vertex of the ovum, and resting on a more translucent part of the ovum. *b,* White pellucid base by which the ovum fixes

and expands. *c,* The part where the white base commences, and where the ciliæ seem to terminate.

Fig. 29. Appearance of the young *Spongia panicea,* after the ovum has fixed and spread for fourteen days on a watch-glass. *a,* Central opaque part to which thc spicula were at first confined. *b,* Transparent homogeneous margin by which the young sponge spreads, and which likewise produces spicula. *c,* Halo of accumulated sediment frequently seen round the margin, at a little distance from the young sponge, and inclosing a cleared space, as in Fig. 27. *d,* The part where the monade-like parenchymatous matter terminates, and where the colourless homogeneous matter commences.

Enumeration of the Instruments requisite for Meteorological Observations; *with Remarks on the mode of conducting such Observations.* By Professor Leslie.

Every meteorological observatory, if it shall register with accuracy, and in a complete and satisfactory manner, the various atmospheric phenomena, ought to be provided with the following instruments.

1. The *barometer*, which measures the pressure of the atmosphere ; 2. The *thermometer*, which indicates its degree of heat ; 3. The *hygrometer*, which marks its relative dryness ; 4. The *atmometer*, which measures the quantity that evaporates in a given time from the surface of the earth * ; 5. The *photometer*, which indicates the intensity of the light transmitted from the sun, or reflected from the sky ; 6. The *æthrioscope*, which detects the cold showered down from the chill regions of the higher atmosphere ; 7. The *cyanometer*, which designates the gradation of blue tints in the sky ; 8. The *anemometer*, which measures the force and velocity of the wind ; 9. The *ombrometer* or *rain-gauge*, which marks the daily fall of rain, or haill, or snow ; 10. The *electrometer*, which indicates the electrical state of the air ;

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* In a close room or sheltered in external air, the atmometer might supply the place of an hygrometer ; and compared with another one freely exposed, it might serve as a substitute for the anemometer.

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Grant, Richard E. 1826. "Observations on the Structure and Functions of theSponge." *The Edinburgh new philosophical journal* 2, 121–141.

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