NATURAL HISTORY OF ANIMALS.

THE

NATURAL HISTORY OF ANIMALS;

BEING THE SUBSTANCE OF

THREE COURSES OF LECTURES

DELIVERED BEFORE

THE ROYAL INSTITUTION OF GREAT BRITAIN.

BY

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LADY ROSS,

THE FOLLOWING PAGES ARE INSCRIBED

BY

HER AFFECTIONATE BROTHER,

T. RYMER JONES.

PREFACE.

The present Work owes its origin to the flattering manner in which the lessons it contains were listened to by numerous and attentive audiences in several of the leading Institutions in the Kingdom, before whom the Author has endeavoured to simplify and render popular the subject upon which it treats. The following pages contain, in fact, the substance of the Fullerian Lectures on Animal Physiology, delivered during three successive years in the theatre of the Royal Institution of Great Britain. May they, in their present form, obtain at the hands of the Public the same indulgence which was bestowed upon the Writer by those to whom, as lectures, they were originally addressed!

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ON

NATURAL HISTORY.

CHAPTER I.

It is impossible that any person, however thoughtless and unaccustomed to observe the works of Creation, can look around him, even during a morning's ramble through the fields, without being struck with the number of living beings that offer themselves to his notice, presenting infinite diversity of form, and obviously adapted, by their construction and habits, to occupy various and widely different situations. The careless lounger, indeed, untaught to mark the less obtrusive and minuter features of the landscape, sees, perhaps, the cattle grazing in the field; watches the swallows as they glance along, or listens with undefined emotions of pleasure to the vocal choir of unseen feathered songsters; and, content with these symptoms of life around him, passes unheeding onwards. Not so the curious and enlightened wanderer, inquisitive to understand all that he finds around him: his prying eye and mind intelligent not only can appreciate the grosser beauties of the

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scene, and gather full enjoyment from the survey, but perceive objects of wonder multiply at every step he takes — the grass, the trees, the flowers, the earth, the air, swarm with innumerable kinds of active living creatures — every stone upturned reveals some insect wonder; nay, the stagnant ditch he knows to be a world wherein incalculable myriads pass their lives, and every drop to swarm with animated atoms, able to proclaim the *Omnipotent Designer* loudly as the stars themselves.

Is it upon the sea-shore that the student of nature walks? Each rippling wave lays at his feet some tribute from the deep, and tells of wonders indescribable — brings corallines and painted shells, and thousand grotesque beings, samples left to show that in the sea, through all its spacious realms, life still is found — that creatures there exist more numerously than on the earth itself, all perfect in their construction, and, although so diversified in shape and attributes, alike subservient to the general welfare.

And yet how few, even at the present day, turn their attention to this wondrous scene, or strive at all to understand the animal creation — to investigate the structure and contrivance that adapt each species to perform certain important duties — to perceive the uses and relations of each group — to contemplate the habits and the instincts that direct the different tribes—and, lastly, to trace out the means whereby the mighty whole, formed of such diverse parts, is all along preserved in perfect harmony!

The study of Natural History and of Animal Physiology is confessedly one of the grandest as well

as the most difficult of sciences. To understand the laws whereby even the human body is built up, lies not within the power of human industry or human research; much less to comprehend the lengthy series of creation that extends from man, the most exalted form of living beings, down to the apathetic sponge, which, fixed upon a rock, seems equally deprived of sense and motion. But because we are, and ever must be, unable to grasp the full extent of so magnificent a subject in all its details, let us not despair of gaining much important knowledge from its contemplation, whilst, as is our present purpose, beginning with the first appearances of life, we endeavour, step by step, to trace out the most conspicuous forms, the attributes and distribution of the animals inhabiting our globe, marking their progressive advancement in intelligence and happiness, and exhibiting the development of their faculties from the simplest to the most perfect conditions under which they exist.

Preparatory to entering upon a journey so extensive as this, it is, however, necessary to pause for a few moments, in order to investigate its limits, and, standing, as it were, upon some elevated spot, endeavour to map out as far as we can the regions over which we are about to travel.

But a serious question presents itself for solution even as we make this preliminary survey. What is an animal? Amongst all the forms of organized or inorganic substances how are we to define precisely what an animal is, so as at once to identify it as such and distinguish it from a mineral or a vegetable?

Linnæus, the founder of our science in modern times, thought that, by an axiom in every way worthy of the mind that gave it birth, he had fully and completely settled this important inquiry. The celebrated axiom of Linnæus, as the reader may probably remember, was this: "*Stones grow, vegetables grow and live, animals grow, live, and feel!*" *To be capable of feeling*, therefore, was the characteristic chosen by this illustrious naturalist whereby to distinguish an animal from any other organized substance. But, alas! we shall soon find, as we contemplate the humblest forms that are now admitted into the animal creation, an entire absence of this character, as far, at least, as we have the means of judging. How are we to prove, for instance, that *Sponges*, while in their living state, possess sensation? You may tear them or cut them; bore them with a red-hot iron; attack them with chemical stimuli of any kind; yet, lacerate and torture them as you will, they will never shrink under the inquisition, or confess by the slightest tremor that they are possessed of feeling or capable of sensation. On the other side, look at the vegetable kingdom. See we not that many plants appear to feel the solar influence, turning their flowers to the beams of the sun, or directing the fibrils of their roots in search of nourishment? Does not the sensitive-plant shrink at the slightest contact? If we are to judge of the possession of the power of feeling from the movements caused by external impressions, there are members of the vegetable world that have far more claim to the title of animals than many of the humbler creatures now unhesitat-

ingly classed by the Zoologist as belonging to his department of creation.

To possess the faculty of moving from place to place has been said by some authors to be the peculiar attribute of an animal. The plant, say they, is rooted and fixed; the animal is endowed with locomotion, and able to rove about in search of food. But even this distinction, we shall hereafter see, fails in very numerous instances. In the animal series there are living beings that are immovably attached to some external object during the whole period of their existence, and seem to be as devoid of locomotive power as any vegetables. Again, on the contrary, there are plants that evince this faculty, and are, to a certain extent, capable of changing their situation; consequently, this second characteristic is as insufficient as the former.

Perhaps the best definition of an animal that has yet been offered is, *that animals are possessed of an internal receptacle for food, wherein they collect the nutriment destined for their support;* in other words, that animals are provided with a stomach, while plants are only permeated by tubes, through which the nutritive juices flow equally to every part. But, unfortunately, in the very first class of animals that awaits our notice, the SPONGES, there is no internal reservoir of aliment whatever, nor anything that can be compared to a stomachal cavity; so that our attempts at discrimination are once more baffled.

Chemistry has been appealed to, in order to solve this important question. We are told that animal substances contain an abundance of *Azote*, or *Nitro-*

gen, in their composition, while vegetables do not furnish that element: — that the existence of the azote in question causes animal matter to emit a smell like burned horn when fire is applied, a circumstance that is said to be sufficient to identify it. This, to say the best of it, is but a clumsy distinction, and, moreover, is open to fatal objections; for there are vegetables that contain azote, and that, perhaps, as abundantly as many animals. In the midst of these difficulties, modern science has had recourse to an entirely new line of investigation, which, doubtless, will ultimately yield important results connected with so intricate an inquiry. This is based upon the different appearances presented by the *tissues* or component structures of animals and vegetables respectively when they are accurately examined under high magnifying powers; and, as an instance of the success that may be anticipated to result from this line of research, as well as of the near approximation between the animal and vegetable kingdoms, even in outward appearance, one example will be sufficient for our present purpose. The *Corallines* are, for the most part, decidedly animals, and many of them, as we shall hereafter see, animals of very complex organization; but several of these, *e. g. Corallina opuntia* and *C. officinalis*, which, from their almost exact resemblance to Zoophytes, were supposed to have the same structure, and were unhesitatingly admitted by Cuvier into the animal series, have been found, by examining them with a microscope, after the hard calcareous matter is dissolved out of them, to belong

to the vegetable world; inasmuch as they are composed of vegetable cellular tissue, which, having a peculiar arrangement, is readily distinguishable. Thus, therefore, when we are better acquainted with the microscopic appearances of the different tissues that enter into the composition of organized substances, important facts, calculated to throw light upon the subject we are now discussing, may reasonably be expected.

But we must advance a step further yet, before we have fully laid before the reader the difficulties that attend this piece of investigation. It has recently been stated, and apparently upon good foundation, that there are organized forms that are vegetables at one period of their existence and animals at another. Many of the *Confervæ*, for example, are equally claimed by Zoologists and Botanists; and some among these, as the *Oscillatoriæ*, are said to be possessed of locomotion in one stage of their growth, while in another they are fixed and motionless. So nearly, then, do the animal and vegetable worlds approximate, remote and separate as they appear to be when examined only in their typical forms. Light and darkness are distinct from each other, and no one possessed of eyesight would be in danger of confounding night with day; yet he, who looking upon the evening sky would attempt to point out precisely the line of separation between the parting day and the approaching night, would have a difficult task to perform. Thus is it with the Physiologist who endeavours to draw the boundary

between these two grand kingdoms of nature; for so gradually and imperceptibly do their confines blend, that it is at present utterly out of his power to define exactly where vegetable existence ceases and animal life begins.

CHAPTER II.

ON SPONGES, THEIR VARIOUS FORMS AND GENERAL HISTORY.

Having, in the preceding chapter, confessed our ignorance of any characters that essentially distinguish an animal from a vegetable, we are reduced to the necessity of conventionally allotting to the Botanist a certain share of the organized creation, whilst, as Zoologists, we take to ourselves the contemplation of the remaining portion: our next inquiry must, consequently, be concerning the point at which the division is to be made.

It appears that, by the almost universal consent of modern Naturalists, all those marine and fresh-water productions called Sponges have been grouped together in one extensive class, and assigned to the share of the Zoological student as the lowest beings to which the name of animal is rightly applicable: how far they are entitled to the appellation, we must, therefore, now proceed to inquire.

All sponges are inhabitants of the water, and for the most part they are marine. Some forms encrust the surfaces of rocks, on which they spread themselves like a soft and living carpet; others, attached to stones, or coral branches, swell into large and shapeless masses: some, exquisite in texture, fix

themselves upon the roofs of ocean-caverns, and thence hang down like living network in the tranquil sea; or, moulded into cups and strange fantastic arborescent shapes, exist abundantly in every climate.

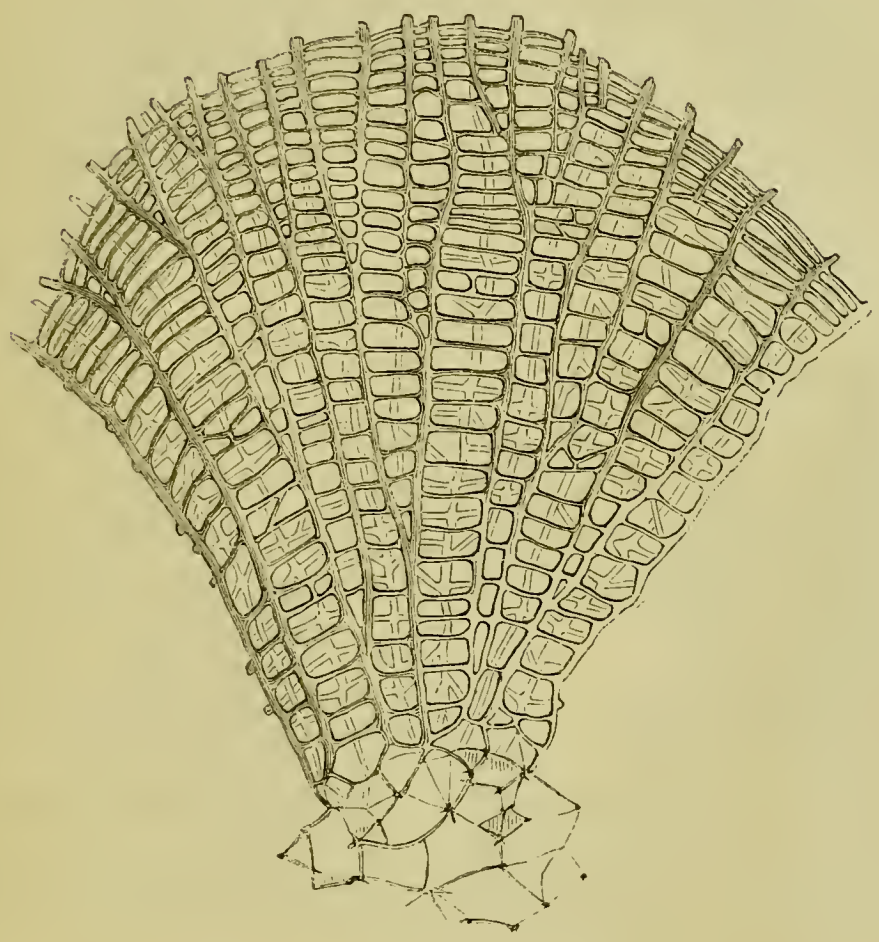
Fig. 1.

The common sponges, (fig. 1,) with the appearance and texture of which, when in a dried state, every one is familiar, we shall, on that account, select for special description, as being well calculated to illustrate what is known concerning the history of the entire class.

The sponge of commerce *(Spongia officinalis)* is entirely composed of a most intricate interlacement of horny filaments, between which water passes freely through all parts of the spongy mass. When highly magnified, the manner in which these filaments unite in every direction with those around is distinctly seen; and the annexed figure (fig. 2) will give the reader a very correct idea of the appearance of a minute portion of horny sponge, thus exhibited under the microscope, and show that its entire substance is made up of countless minute intercommu-

nicating cells circumscribed on all sides by the horny meshes.

Fig. 2.



The horny network, above described, is, however, only the framework or skeleton upon which the living portion of the sponge is supported and spread out. Whilst the sponge is alive, or recently detached from the rock on which it grew, every filament is found to be coated over with a glairy albuminous film, almost as liquid as oil or as the white of an egg, and it is this semi-fluid film which constitutes the living portion of the creature; being endowed with the power of absorbing nourishment from the sur-

rounding water, and, as it grows, of forming for itself a horny support which it arranges in definite and beautiful forms, characteristic of the species to which it belongs.

If the living sponge, thus constructed, be examined while in its native element, it is seen to be possessed of faculties and capabilities of a most extraordinary and inexplicable character. It was, I believe, Professor Bell who, many years ago, first announced in a paragraph in Nicholson's Journal, that, when the sponge is watched in its natural condition, its substance is seen to be permeated in all directions by strong currents, the course of which may be easily made apparent by diffusing a little powdered chalk, or other opaque particles, through the surrounding water.

Professor Grant has more recently and more minutely examined this part of their economy; and it is, indeed, principally to his patient observations that we are indebted for such a history of sponges as induces modern Zoologists to classify them as members of the animal creation.

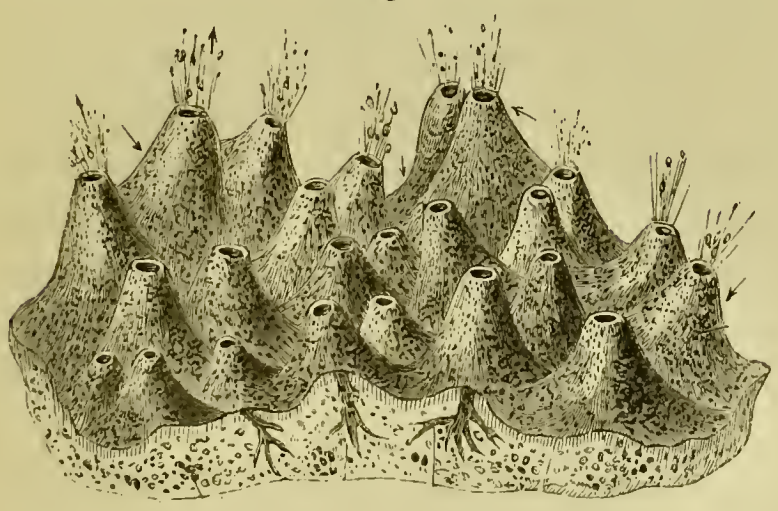
By a careful examination of living sponges, the last-mentioned observer ascertained that the water wherein the sponge is immersed is perpetually sucked into its substance through the countless minute pores that cover its outer surface, and as incessantly is again expelled through other and much larger orifices, that are placed at distant intervals upon prominent portions of the body of the sponge *(see fig. 1)*. In the accompanying figure (fig. 3), copied from Professor Grant's paper, the course and appearance of

these currents are indicated. The water sucked in by the general porous surface is gradually collected by some inherent and vital power of the sponge into larger and still larger channels, and at length is forcibly ejected through the wide openings that are indicated in the figure by issuing arrows.

Fig. 3.

(The account given by Professor Grant of his first discovery of these entering and issuing currents is extremely graphic. Having placed a portion of live sponge *(Spongia coalita)* in a watch-glass with some sea-water, "I beheld," says he, "for the first time the splendid spectacle of this living fountain (fig. 4) vomiting forth

Fig. 4.



from a circular cavity an impetuous torrent of liquid matter, and hurling along in rapid succession opaque masses which it strewed everywhere around. The beauty and novelty of such a scene in the animal kingdom long arrested my attention; but after twenty-five minutes of constant observation I was obliged to withdraw my eye, from fatigue, without having seen the torrent for one instant change its direction or diminish the rapidity of its course."* In observing another species (*Spongia panicea*), he is still more exact in describing so interesting a phenomenon. "Two entire portions of this sponge were placed together in a glass of sea-water, with their orifices opposite to each other at the distance of two inches; they appeared to the naked eye like too living batteries, and soon covered each other with the materials they ejected. I placed one of them in a shallow vessel, and just covered its surface and highest orifice with water. On strewing some powdered chalk on the surface of the water, the currents were visible to a great distance; and, on placing some pieces of cork or of dry paper over the apertures, I could perceive them moving by the force of the currents at the distance of ten feet from the table on which the specimen rested.")

In a singular form of sponge (*Leuconia compressa*) the process is somewhat modified. This species (fig. 5), which is fusiform and hollow, receives the surrounding water through innumerable pores distributed over its outer surface, which, after percolating the

* Jameson's Edinb. Phil. Journal, vol. xiii.

Fig. 5.

substance of the mass, escapes into the internal cavity, (fig. 5, *b*,) whence it is ejected in a large stream from the wide orifice (*d*) situated at one extremity.

We are here naturally curious to inquire, what is the cause of this constant flow of water through the sponge? That the currents in some species are thus conspicuous, has been testified by several observers; but we are even now entirely ignorant concerning the motive power employed to produce such a circulation. Some of the older Zoologists tell us that the substance of the sponge, when microscopically examined, is found to present contractions and dilatations in some measure comparable to those of a living heart, whereby the gushes of water are produced; but more recent and accurate observers have satisfactorily proved that no such contractions are perceptible. Ciliary movement, a phenomenon that we shall minutely investigate hereafter, has been suggested in explanation of the circumstance, but the most powerful glasses do not reveal to us the presence of those wonderful vibratile filaments known to produce similar currents in other animals.

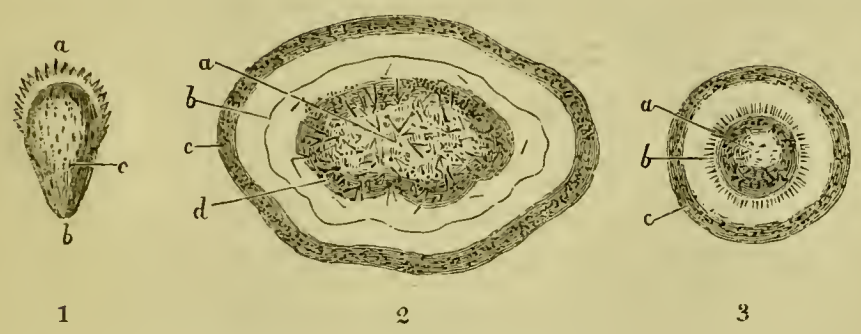
It is doubtless from the water, that, in the manner above described, traverses every part of its interior, that the sponge derives the materials for its nourishment. Particles of organized matter are thus continually introduced; and probably the living film,

that coats every portion of the extensive surface presented by the intricate skeleton or framework, may be endowed in some mysterious way with the power of digesting such nutriment and of converting it into its own substance. Let us, however, complete the general history of sponges before we direct our attention to particular members of this strange class of living beings. During certain seasons of the year, on making a section through the substance of some sponges, as Dr. Grant informs us, innumerable small granules of gelatinous matter will be seen sprouting in all directions from the living film that invests the horny skeleton; and these granules or globules speedily increase in size, until they form minute masses of jelly, which in shape and size are comparable to pins' heads. At length they become detached from the nidus where they grew, and, escaping into some of the currents issuing from the sponge, they are whirled away and projected into the sea (fig. 3, *b*, *b*).

The globules referred to, or *gemmules* as they are technically called, are, in fact, so many young sponges, which, having sprouted as buds from their plant-like parent, are to be conveyed to a distance and disseminated through the surrounding ocean. But how is this to be accomplished? The adult sponge, from whence the gelatinous gemmules are derived, is cemented to the rock, fixed, and, as we have seen, absolutely motionless and devoid of contraction, and consequently incapable of carrying the offspring from place to place, or of assisting in effecting their dispersion. The young sponges, therefore, the

gemmules themselves, must be endowed with some means of locomotion, and gifted with powers of which the animal that gave them being is totally destitute; accordingly, instruments of progression have been supplied to the nascent sponge of a most wonderful and mysterious character. Before breaking loose from the gelatinous substance of the parent, these gemmules, as Professor Grant assures us, are found to assume an ovoid form (fig. 6; 1, *c*); and, while the

Fig. 6.



narrow extremity of each (*b*) is still attached, the opposite end (*a*) is seen to be covered over with innumerable microscopic filaments, resembling hairs, of infinite minuteness, but every one instinct with life and capable of rapid motion. These hairs, or *cilia* as they are termed, moved by some innate power, vibrate continually; and in this way, by the co-operation of thousands of almost invisible oars, the gemmule is torn from the substance of the sponge where it was formed, and, having been driven into the surrounding water, shoots like a microscopic meteor through the sea to a considerable distance from the place of its birth. Having, at length, arrived in a locality proper for its future development, the little gemmule settles down upon the surface of some rock and spreads out into a

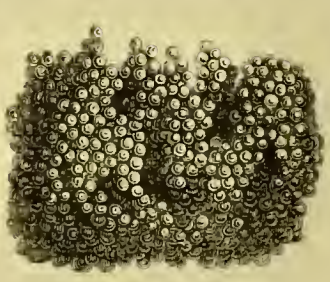
film (fig. 6; 2, *a*, *b*, *c*); its wonderful apparatus of oars soon disappears, and, deprived of all power of locomotion, it gradually spreads, begins to form within it the *horny* or other framework peculiar to its species (fig. 6; 3, *d*), and soon presents the same appearance, and arrives at the same dimensions, as the original from whence it sprang. (It would seem, however, from the observations of Dr. Johnston, the accurate and learned author of a History of British Sponges, that the ciliated gemmules described by Dr. Grant are by no means met with in all species, although he admits the accuracy of Dr. Grant's views with respect to some. Dr. Johnston has likewise well described the way in which sponges are developed from the gelatinous globule whence they originated, a process that appears to be effected in the following manner:—The little sponge, according to Dr. Johnston's account,* begins as a spot-like crust of uniform texture, porous throughout, and nearly equally so; yet even in this primitive condition there is a perfect circulation established, a current which seeks the interior, and another which flows from it to mix with the circumfluent medium. As the sponge grows in extent and depth, the space for imbibition is enlarged; and the centrifugal water in its efflux, flowing at first into one, and then into more currents, these gradually make for themselves channels in the cellular texture, the fibres of which are pushed aside, and prevented by the continuance of the stream from again encroaching on its course. The channels increase in number with the continued growth of the

* History of British Sponges and Lithophytes, pp. 90, 91.

sponge; and, as it cannot but happen that they shall occasionally open into and cross each other, we have a wider canal formed by the additional flow of water into it. Such of these canals as reach near the surface soon effect for themselves a wide opening there; for the issuing current continually pushes against the superficies of the sponge which opposes its efflux, and gradually thins and loosens its texture until this ultimately disappears, leaving a wide orifice or *osculum*. This is frequently a simple circular hole, but often, on looking within the outer rim, we notice in it from two to five lesser *oscula* united together, which are the openings of so many canals that have united there; and sometimes we find spread within the osculum, or over its mouth, a network of finer texture than the rest of the sponge, but otherwise of the same nature and composition. The form of the *oscula* (fig. 3, *b*, *b*), through which the currents issue from the interior of the sponge, depends entirely on the texture of the species and on the force of the effluent currents. If the texture be loose and fibrous, it yields easily, and the oscula are level or nearly so; if more compact, the skin is pushed beyond the surface into a papillary eminence; and, if too firm and dense to yield to the pressure behind, the oscula fall again into a level condition. They are also liable to be modified in some degree by external circumstances; for the littoral sponge, which, in a sheltered hollow, or fringed pool, will throw up craters and cones from its surface, as in fig. 4, may be only perforated with level oscula when it is swept over and rubbed down by the waves of every tide.)

From the received history of the common sponge, as given above, there would appear to be little difficulty in admitting beings so organized to appertain to the animal series of creation; but, even granting some of the highest forms to be entitled to the name of animals, it is by no means easy to admit that all the substances called sponges are equally worthy of the appellation. There are, for example, what are called "*gelatinous sponges*," that do not present the reticulated structure we have alluded to, but, when examined under the microscope, rather resemble the tissue of plants, as represented in the accompanying figure (fig. 7); and, on the other hand, there are sponges, the reticulations of which are so delicate and so widely apart, that it would be difficult to imagine them at all capable of producing currents such as those above described. Such forms, most probably, ought to be regarded as members of the vegetable kingdom.

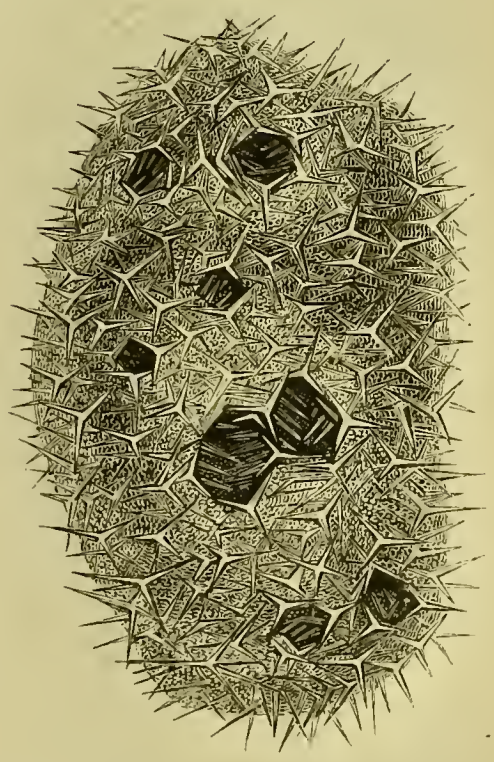
Fig. 7.



In the sponge of commerce, and other allied species, the entire framework, as we have seen, consists of a horny substance, which, from its flexibility and resiliency, becomes extremely useful to mankind, and is an important article of commerce; but there are various other kinds of sponge, that are utterly worthless in a commercial point of view, having their skeletons supported by silicious or calcareous particles, produced from the surrounding water, and deposited in a crystallized form throughout the sub-

stance of the sponge, imbedded in a tough fibrous material that binds them together. On destroying the soft portions of such sponges, by burning them, or by solution in a corrosive acid, these crystals are easily obtained in a separate condition ; and, if examined under a microscope, will be found to present definite shapes, which are occasionally characteristic of the species of sponge to which they belonged. A portion of one of these silicious sponges is represented in the annexed figure (fig. 8), and all the spicula diffused through its substance are found to assume the appearance of spines radiating from a common centre. In other species the spicula are merely straight or curved needle-like bodies, or they have heads like pins, or resemble minute rows of beads; but, whatever their form, it is more or less constant and invariable, in so much that, to use an expression of Professor Grant, a few of them brought from any part of the world upon a needle's point would enable the Zoologist to identify the species to which they originally appertained; an assertion, however, that must be received with very considerable limitations.

Fig. 8.



The presence of silicious spicula thus diffused

abundantly through the entire substance of sponges possessing a skeleton of this description, unimportant as the circumstance may seem at first sight, enables the Geologist to give an unexpected, but very satisfactory, explanation of the origin of those detached and isolated masses of flint, which in various chalk-formations are so abundantly met with, arranged in regular layers through strata of considerable thickness. The mere assertion, that flints were sponges, would no doubt startle the reader who was unacquainted with the history of those fossil relics of a former ocean; but we apprehend that a little reflection will satisfy the most sceptical of the truth of this strange announcement. Imbedded in the substance of the chalk, which, during long periods, by its accumulation had continued to overwhelm successive generations of marine animals, the sponges have remained for centuries exposed to the water that continually percolates such strata—water which contains silicious matter in solution. From a well-known law of chemistry it is easy to explain why particles of similar matter should become aggregated, and thus to understand how, in the lapse of ages, the silicious spicula that originally constituted the framework of a sponge have formed nuclei around which kindred atoms have constantly accumulated, until the entire mass has been at last converted into solid flint. We are, moreover, by no means left to mere conjecture or hypothesis upon this interesting point; nothing is more common in chalky districts than to find flints which, on being broken, still contain portions of the original sponge in an almost unaltered

condition, and thus afford irrefragable proof of the original condition of the entire mass.

From the history of sponges we thus learn the following important facts, connected with and elucidating subsequent parts of our subject:—A film of gelatinous consistence, possessing no stomach and spread out upon a framework of its own construction, has the power of nourishing itself and of separating from the sea, in which it is immersed, particles of a horny, calcareous or silicious nature, and of building up by means of these materials a peculiar structure called a sponge.

With these facts before us, relative to the capabilities of living matter, we are prepared to investigate the next forms of creation that nature offers to our inspection.

CHAPTER III.

ON AGASTRIC ZOOPHYTES, FUNGIÆ, MEANDRINÆ, HISTORY AND PROPERTIES OF THE HYDRA VIRIDIS.

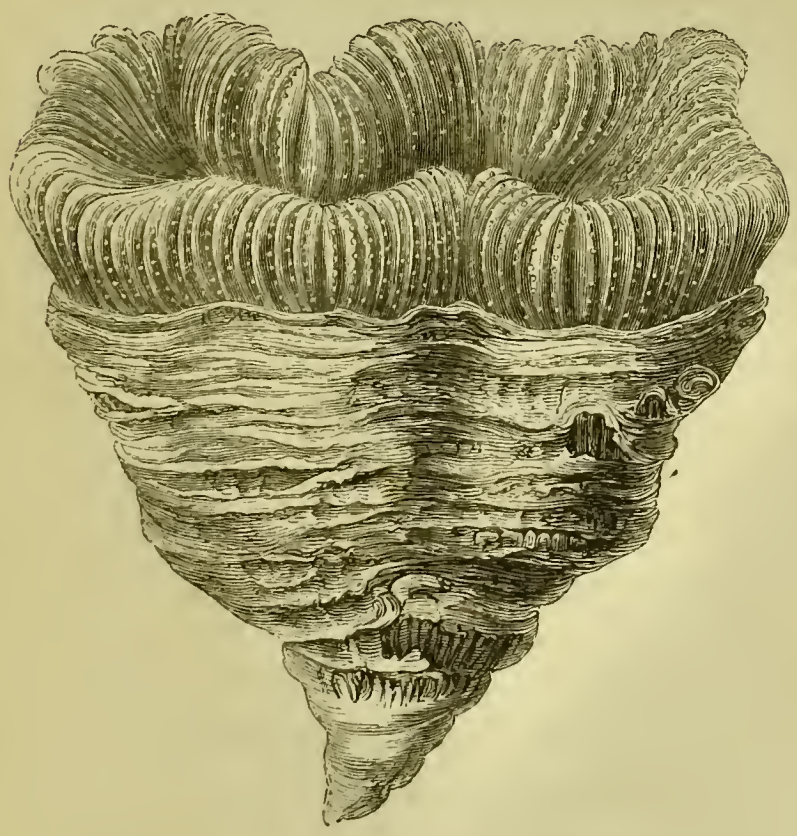
THE creatures that now present themselves for description are so nearly related to the sponges, described in the last chapter, that, notwithstanding their different appearance, in strict physiology it is difficult to separate them. They are universally allowed to be animals, but yet are completely without the power of motion ; neither have they a stomach or any digestive cavity whatever ; consisting simply of a living gelatinous film, which is endowed with the capability of constructing for itself a stony support or framework, that is derived from the surrounding water and moulded into various beautiful shapes ; each, however, built upon precise principles and strictly characteristic of the species to which it belongs.

The FUNGIÆ (fig. 9) are remarkable for their beautiful and mushroom-like skeletons ; although concerning their history, while in a living state, little has been accurately recorded by modern Naturalists.

The upper surface of one of these creatures is formed of numerous vertical calcareous plates, which, whilst in a living state, sustain and support the

animal. When recently taken from its native element, every one of the delicate laminæ represented in the figure is found to be crusted over with a living gelatinous film; a film so delicate that its existence can scarcely be perceived, except upon the most accurate investigation, and yet, almost imperceptible as it is, it is nourished by its own vital energies. It absorbs from the ocean by means of its whole surface, and not through any mouth, the materials necessary for its sustenance. It expands and spreads in all directions, and, as its growth proceeds, it moulds within its substance the exquisitely beautiful skeleton that belongs to its species. Various forms of these

Fig. 9.



beings are met with in tropical seas, and some of them present different arrangements of the laminæ of the skeleton, from that exhibited in the species here figured; but all of them agree in these points, that the animals have no power of voluntarily moving from place to place, neither are they possessed of any mouth, of any cells, or of any apparent means of seizing and digesting food.

If, however, we investigate the history of the Fungia a little more closely, it is beautiful to observe in, apparently, one of the most helpless and useless members of creation, the operations of the same power and foresight that shield and guard the highest and most intelligent. The fungia, whilst it is alive, lies upon the sand at the bottom of the shallow seas of warm climates, or has its base loosely imbedded in the sand. It is unattached by any pedicle or root, so that a passing wave of any violence might easily take it up and wash it to a distance from the spot it originally occupied. This being the case, what is to prevent the wave from turning it upside down? It is only upon the upper surface that the living crust is spread, which forms the fungia, so that should accident reverse its position the creature would inevitably perish. The arrangement adopted to prevent such an occurrence is simple enough, but not on that account less beautiful. The living film that coats its laminated surface has the faculty of secreting little bubbles of air within its substance; the bubbles so produced although disseminated, as it were at random, are sufficiently buoyant to act as floats, and thus provided

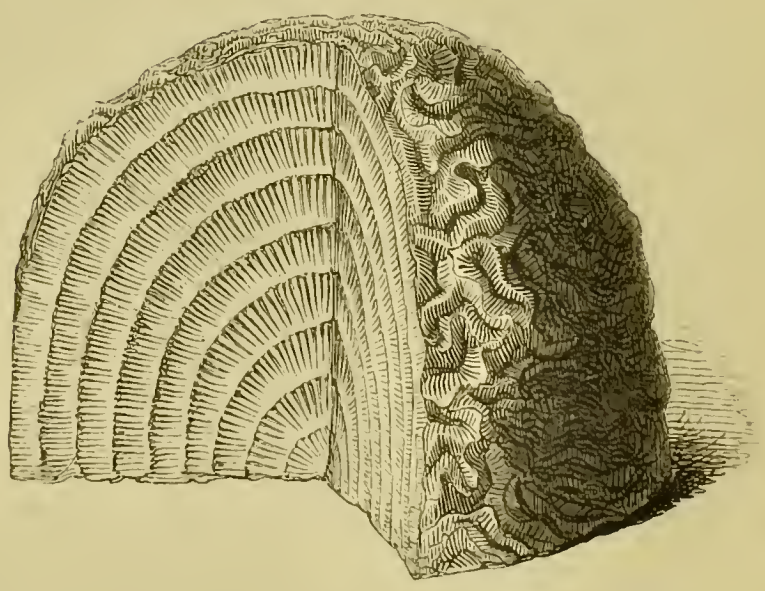
let the wave wash it ever so far, still the lightest side keeps uppermost, the floats prevent it from being reversed, and the creature settles down again in a right position upon the smooth bottom of the sea.

Physiologists of the present day tell us that the calcareous framework that supports the fungia is absolutely without vitality, dead, and as much removed from all influence of the living part of the animal as the rock upon which it rests. Let us, however, beware of setting out with this erroneous impression upon our minds, or we shall find it difficult to understand the phenomena that occur in higher forms, to which we shall be gradually led on; let us rather take the earliest opportunity of proving that these skeletons are not dead, or beyond the reach of vital action, but are still subject to the influence of the delicate film that secreted them. In order to be convinced of this, it is only necessary to observe the manner in which the young fungiæ are formed,—a process accomplished exactly in the same way as in the simplest plants. Upon some portion of the living surface of the parent there appears a little bud, a gelatinous prominence, a sprout, if we may so call it; and this, gradually increasing in size, spreads out like a young mushroom, and assumes the form of the original, to which it is attached by a solid pedicle of calcareous matter. Having, however, attained to a sufficient size, the separation between the parent and the young must be effected; an operation which obviously cannot be explained upon the supposition that the connecting pedicle is dead, and incapable

of being acted upon by the living parts. It is evident that the newly-formed animal, having constructed within itself the mould whereon the film composing its body is spread out, by its own vital power absorbs and removes the stem that had hitherto supported it, and, having dissolved the earthy materials that it first laid down, the young fungia assumes a separate and independent existence.

We have thus advanced one step higher in creation, and not even yet arrived at those forms of organization which we should be disposed, unhesitatingly, to admit into the animal series. But to proceed. Nearly allied to the Fungiæ in the texture and stony hardness of their skeletons are those beautiful calcareous structures called MEANDRINÆ, or *brain-stones*, one of which, the *Meandrina cerebriformis*, is represented in the adjoining figure (fig. 10). The

Fig. 10.



skeleton of the meandrina is a large and ponderous hemispherical stony mass, the periphery of which is deeply indented with large and flexuous sinuosities, containing innumerable minute vertical plates, composed of a hard earthy substance.

While in a living state, the entire convex aspect of the mass represented in the figure, and all the sinuosities that characterize its surface, were covered over with a vitalized crust, resembling in texture that which is found to invest the laminæ of a recent fungia, and endowed with similar powers. The living film referred to is still gelatinous in texture, but is seen to be covered with filamentary processes, apparently the first appearances of tentacula or instruments for seizing prey, although these are not yet arranged so as to drag food into a stomach, since no such cavity exists. On making a section of the brain-stone, as represented in the figure, the manner in which the entire fabric has been constructed becomes at once manifest. Originally, when first deposited upon the rock whereunto it attached itself, the young meandrina covered only the minute nucleus forming the centre of the mass; but as its growth proceeded, as the living crust went on extending and developing itself, by depositing beneath it a continually increasing accumulation of stony matter, it has gone on gradually building the admirable structure delineated, having occupied successively the superficies of every stratum indicated in the figure, and would have gone on growing and extending in the same manner until it had attained the diameter of two or three feet, or more. Such are the powers

conferred upon that delicate tissue, almost gelatinous in its appearance, that constitutes the living portion of these humblest members of the animal kingdom.

But now we have arrived at less dubious forms of organized beings, where the question as to whether the creatures are animals or vegetables is no longer a subject of dispute, and must prepare ourselves to examine the earliest conditions under which life presents itself to the contemplation of the Naturalist. The most simply-constructed animal that can be imagined is one deprived of all superfluities of organization, of all limbs, of all senses, of all organs and appendages but such as are indispensable to existence. What is the portion of an animal, therefore, that can exist independently of the presence of all others, —the last remnant, if we may so express ourselves, after all superfluities have been removed? However startling the announcement may appear to many of us, we are compelled reluctantly to admit that the presence of a stomach is all that is absolutely requisite. A stomach, providing it can live, is an animal. All appendages, all complexities of structure, are but superadditions to this primary portion of the creature; and, providing it can feed itself, it wants nothing more to be capable of enjoying an independent being.

Let us, however, proceed to present to the contemplation of the reader a creature of the simple character alluded to; but, simple as is its construction, the pride of human philosophy may well be humbled when it attempts to understand the capabilities conferred upon this mere stomach. The HYDRA, or

fresh-water Polyp, is found abundantly in our stagnant pools of fresh water, adhering to the floating leaves of duck-weed, or to the stems of plants. The species most usually met with in this country (*Hydra viridis*) is easily obtained, by simply taking up in a large tumbler-glass some of the water in which they are found, together with the confervæ upon its surface, and allowing it to remain for some time undisturbed. The hydræ will then be found in an expanded state, and the wonderful circumstances connected with their history readily be made the subject of observation.

The *Hydra viridis*, of which a magnified representation is given in the accompanying figure (fig. 11, *b*),

Fig. 11.

when seen with the naked eye, resembles a minute piece of green sewing-silk, about a quarter of an inch in length, attached by one extremity to the side of the glass and slightly untwisted at the opposite end. On more accurate examination, the body of the little creature is seen to consist of a delicate bag, around the mouth of which is placed a circle of six or seven filaments or tentacles, that are expanded in all directions whilst the hydra is in a state of activity: these tentacles, in our common species, are comparatively short, but in the *long-armed hydra* (fig. 11, *d*) they can be spread out to a considerable distance in search of food. At the other end of the body, or that opposite to the mouth of the bag, is a minute disk that answers the purpose of a sucker, so that by its assistance the little polyp can attach itself securely to any smooth surface.

Examined with a strong lens, the entire body of the hydra appears to be made up of a gelatinous substance, and to consist of greenish globules, floating in a more transparent fluid: even the tentacula exhibit the same structure; and, during the performance of those slow and languid movements of which the creature is capable, the enclosed globules are seen continually to change their position and move from place to place in the interior of the animal. Such is the little being, upon the history of which we are now entering; a creature possessed of the most extraordinary faculties, and endowed with attributes almost incredible.

It is capable of moving from place to place — but how? If we are asked how animals move, our answer

would be, doubtless,—by means of their muscles. Nevertheless, the hydra before us has no muscles—not a filament of muscular fibre is to be detected in its gelatinous structure; yet, notwithstanding, its means of locomotion are various and sufficiently perfect. Upon a smooth surface it progresses after the manner of a leech: first fixing itself by the sucker at its tail, it slowly inflects its body so as to take hold of the plane of progression by means of the tentacles around its mouth; having accomplished this, it again detaches, and brings forward the sucker at the opposite extremity; thus marching steadily along, slowly indeed, but with sufficient rapidity for its ordinary purposes.

When we consider the minute size of the hydra, and the slowness of its contractions, it is obvious that, to proceed but a few inches in the manner above described, would occupy many hours; if, therefore, it chooses to make a more speedy transit than its ordinary occasions require, it adopts a different plan, and, constructing a boat for itself, rows about from place to place. Protruding the little sucker at its tail just above the surface of the water, and then depressing the central part of the disk so as to make it concave, like a saucer, it becomes a float, sufficiently buoyant to support the weight of the hydra; which, swimming thus, rows itself from place to place with the greatest ease by means of its filamentary tentacles.

Being thus endowed with the power of locomotion, we must naturally expect these simple animals to be gifted with a certain degree of sensation, whereby a correspondence with the external world may be main-

tained; and yet, how are sensations to be conferred upon animals apparently deprived of all those organs which are deemed by the physiologist as inseparably connected with their exercise? In the higher animals the presence of a brain, of nerves, of instruments of sense, is essential to the enjoyment of sensation: but in the *hydra*, and other equally simple creatures, the capability of feeling obviously exists without the apparent existence of any of these parts; and even the power of appreciating light has been bestowed without the presence of eyes, or the remotest vestige of a visual apparatus. Whilst watching the movements of the little hydræ, it is soon perceived that they are fond of light; that if one side of the jar in which they are confined be turned towards the light, while the other is left comparatively in darkness, they will undertake long and apparently fatiguing journeys towards the illuminated side, and exhibit sufficient proof that they appreciate the presence of light, although, perhaps, it would be going too far to attribute to them the power of seeing. Such sensation is, no doubt, rather dependent upon the delicacy of their sense of touch enabling them, to use the elegant words of an Italian writer, "palpare la luce," to palp or feel the light.

We might easily be led to suppose, when we contemplate the feeble and sluggish movements of the remarkable beings now under consideration, that their food was proportionately helpless,—inanimate particles of vegetable matter, or at best organized molecules, that are fortuitously brought into their

vicinity; yet nothing could be more erroneous than such a supposition. The food devoured by the hydra consists of extremely active and energetic animals; the larvæ of insects or minute crustaceans, comparatively strong and highly-organized beings, fall an easy prey to its voracity. But how does it seize? how does it hold? how does it overcome creatures so infinitely superior to itself in strength and activity? These are questions of no ordinary interest. If the *hydra* be observed while waiting for food, it is seen to fix itself by the sucker at its tail to the surface of a leaf, or any other support; and in this position it patiently remains, with the tentacula around its mouth; spread out in different directions. Delicate and almost invisible as are the fishing-lines when thus extended, the power that they possess of catching and of holding prey is truly wonderful: no sooner does a passing animal, of suitable dimensions, impinge accidentally upon one of the outspread tentacles, than, suddenly, as if the wand of an enchanter had been laid upon it, by some unseen and inscrutable power its movements are arrested and all its efforts to escape rendered useless; the creature, that a moment before was dashing about through the water, is at once seized and soon made incapable of resistance. The tenacious filament, having thus taken a secure hold, then begins to contract, and slowly, but surely, drags the victim toward the opening of the bag, the mouth of the hydra; other tentacula are made to entwine it as it arrives in the vicinity of the oral orifice, and thus active larvæ of insects, or

even fishes of tiny dimensions, are easily overmastered and swallowed by their apparently contemptible assailant.

(The account given by Trembley of the whole process is too amusing not to be narrated in his own words, especially as it is not more remarkable for its simplicity than for its truth. "In order to see the hydræ catch prey," says this admirable observer, "when the arms of a polyp are well spread out, I put into the glass a *millepede*, (as the larvæ of insects and crustaceans in his time were indiscriminately called,) or other little worm, and force it, by little and little, with the end of a camel-hair pencil, to come in contact with the arm that I wish to catch it. It is enough for the creature to touch it, to be arrested by it. As soon as a millepede finds itself caught, it kicks about vivaciously and struggles hard to get away; often it begins to swim to and fro, and drags the arm that has got hold of it, first to one side and then to another, as a hooked fish darts about with the line. The first time that I witnessed this feat, I expected every moment to see the arm of the polyp broken off by the repeated violent shocks it received, and a part of it carried away by the millepede; but I soon found that, slender as these arms were, they could resist considerable efforts. I never saw a millepede break one, and very rarely succeed in getting off. The struggles of the millepede, however, at last force the polyp to draw in his line; he, therefore, partially contracts it, often twisting it into a cork-screw shape, so as to shorten it the more. The millepede, mean-

while, continues to resist, though by its struggles it only winds the arm that holds it still more closely around its limbs; it is then involved by other arms, brought by the polyp to the assistance of the first, and all these co-operating soon drag the poor animal into the mouth of its devourer. As the prey is swallowed, the stomach of the hydra stretches, its body becomes shortened, broad, and gathered into a heap, (fig, 11, *a*,) the arms are contracted, and the polyp hangs motionless in a sort of stupor (*engourdissement*) until its food is digested, when it soon returns to its original form and is ready for another meal." *

The reader is here probably anxious to inquire what may be the nature of that extraordinary power which thus enables the hydra to lay hold of and completely conquer its prey; but to this question, unfortunately, we are able to offer but a very imperfect solution. Trembley, to whose memoirs upon the history of the polyps in question science is so deeply indebted, was led to conclude that it was the result of some potent adhesive secretion, exuded from the tentacula themselves; and, perhaps, this is the most likely supposition. The same admirable observer nevertheless noticed, that, whatever was the cause of the phenomenon, it could be suspended at the will of the polyp; for after the hydra had seized two or three animals in succession and was thus provided with food, notwithstanding that its fishing-lines still remained stretched out, the crea-

* Trembley. Mémoires pour servir à l'histoire des Polypes d'eau douce, 1744.

tures that came in contact with them under such circumstances were permitted to escape with impunity.

No sooner has the captured victim been dragged to the orifice of the gelatinous bag that dilates to receive it, than it is introduced into the cavity of the hydra, which shrinks so as to embrace it more closely on all sides; and under these circumstances, so thin and pellucid is the distended stomach that covers the included animal, that its existence is scarcely to be distinguished except by the strictest examination. And now another function conferred upon living matter, the nature of which is equally mysterious and unintelligible, is speedily called into operation. The creature swallowed by the hydra, at first clearly seen through the transparent body of the polyp and distinct in all its parts, becomes indistinct and turbid, until at length it is scarcely possible to distinguish its limbs and proportions. The observer is inclined to rub his eyes, or wipe the glasses of his microscope, under the impression that they are becoming dull; but without effect. The process of digestion has begun; slowly and gradually the swallowed creature disappears, and its soft parts are absorbed into the texture of the hydra itself, to be diffused as nutriment throughout its delicate substance.

Even fishes, as we stated just now, are sometimes thus devoured and digested; a fact for which Trembley often vouches. We will again let him speak for himself. "In the month of June, 1743, having caught a great number of little fishes, about four lines (that

is, a quarter of an inch) in length, the first thing that I did was to try if the polyps would eat them.

"I, therefore, put several of them into the glasses where my polyps were, and experience soon taught me that, as I had at first suspected, the strength and activity of the fishes would enable them to make no small resistance; indeed I did not dare to flatter myself that the polyps would succeed in catching them. The fishes, however, in swimming about, soon came in contact with the arms of some of the polyps, and then began furious battles, that did not always end with the same success. When a fish only touched a single filament, it was generally able to disengage itself by a violent effort, and sometimes even broke off the arm that had laid hold of it; but, if caught by several arms at once, the combat took another turn, and the fish, generally, had the worst of it. The struggles that it made to get at liberty were, for the most part, useless, and only served to entangle it more in the arms of its enemy. Still it was easy to see that the polyp had to make great efforts to hold the fish. The tentacles, that enveloped it, were much thickened, and firmly grasped the little minnow on all sides. Even when I saw a polyp had succeeded in mastering a fish, and had dragged it to its mouth, I did not understand how, by possibility, it could be swallowed. A bulky fish, four lines long, which could not be doubled up, had to be taken into the stomach of a little polyp not more than half its own length. However, the hydra, that undertook the task, accomplished it; the tail was

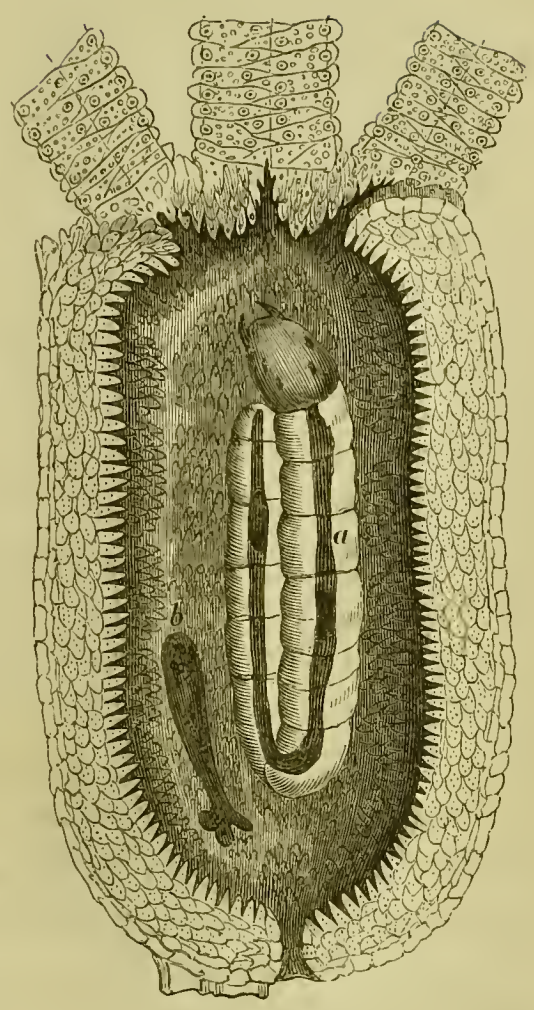
swallowed first, and gradually the whole fish received into the dilatable bag; which being achieved, the polyp was so tensely stretched over the included victim, that, if a person had been ignorant of the fact, he would have thought he only saw a fish, at the anterior extremity of which were a few barbs, some lines in length.

"This little minnow, therefore, was lodged whole in the stomach of the hydra, which became, by the inordinate distension, reduced to a transparent film; nevertheless, it was soon digested. In a quarter of an hour it was killed, sucked, and the remainder ejected from the mouth of the polyp; recognizable, indeed, as a fish, but very considerably mutilated."

We have already stated, that the hydra is a mere bag, presenting no distinction of organs, no complexity of structure. If such, therefore, be the case, why should not the external surface be able to perform the same functions as the internal? Turn the creature inside out, like a glove, and, as Trembley assures us, so little difference is there between the skin and the stomach, that, when thus inverted, the one can take upon itself the office of the other, and the prey continues to be seized and digested with as much facility as before. Nevertheless, Mons. Gervais, in a paper upon the microscopic composition of the creature in question, recently inserted in the Annales des Sciences Naturelles, seems disposed to consider that the structure of the hydra is not so simple as has been supposed; and has given a most elaborate figure, of which a copy is here inserted, illustrative of his views concerning its organiza-

tion. The figure (fig. 12) represents a section of a large species of hydra (*H. fusca*), in the interior of which is the larva of an insect, that has been swallowed. The granules, visible in the texture of the hydra itself, when the creature is thus highly magnified, the author supposes to be appropriated to different offices, and arranged in distinct layers. The internal layer, composed of papillæ which are of a conical form, are regarded as peculiarly subservient to the digestive process: the external layer he naturally enough regards as an integument, while the intermediate granules are dignified by the name of muscular layers. But even from this minute analysis we learn little to explain the wonderful phenomena connected with the history of these interesting animals.

Fig. 12.



The remarkable powers conferred upon the hydra, enabling it to seize, to swallow, and to digest strong and active prey, inexplicable as they are, are de-

pendent, as modern physiologists account for these phenomena, upon *vitality;* that is, upon the capabilities conferred upon living structures by the presence of life; a mode of expression to which we shall but too frequently have occasion to resort in the following pages, and no doubt to the great edification of our readers.

But this mysterious principle, *vitality*, seems only to act in accordance with certain laws, that are equally unintelligible. The hydra, while it digests other animals, has no power of dissolving its own substance. Frequently it will be seen to swallow its own tentacula involved around its prey; but, whilst its victim is digested, the tentacle remains uninjured. Trembley, the illustrious biographer of these strange beings, once observed two hungry hydræ that had seized upon the same animal. One of the hydræ was larger and stronger than the other, and, after having struggled for some time, the larger and more ravenous terminated the contest by swallowing both the disputed prey and its antagonist into the bargain. Trembley was of course prepared to witness a serious termination to this tragical event; he fully expected to see the swallowed hydra dissolved and destroyed by the one which had swallowed it, but he was disappointed. The living hydra could resist the digestive process; the two competitors dissolved the small animal between them; and the largest hydra, having digested his share, permitted his rival to escape out of his stomach, active and, apparently, uninjured.

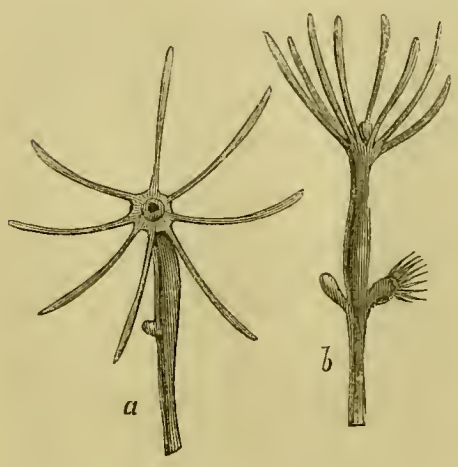
We must not even here terminate the history of the hydra, inasmuch as many other lessons, import-

ant to our present purpose, are to be learned from the phenomena exhibited by these simple creatures. We have already seen that the entire substance of the polyp consists of a kind of soft substance composed of granules, contained in a semi-fluid, transparent jelly. This being the case, it becomes interesting to know in what manner, after the food has been digested in the stomachal cavity, the nutritive materials are absorbed and appropriated to the nourishment of the hydra. Trembley, in the course of his experiments upon this subject, fed his little pets with food of different colours—with the blood-red larvæ of certain insects, for example; and watched attentively, in order that, if possible, he might trace the channels through which the digested matter was taken up. When thus fed with food abounding in red particles, it was soon observed that the green granules throughout the substance of the body of the polyp became coloured with the same red tint, until the whole hydra seemed to be tinged with the new colour; and it was only after the lapse of some time that the floating granules resumed their original appearance. This was all that could be perceived; no connexion was visible between these globules and the stomach, neither were there any apparent channels of intercommunication among the globules themselves.

A still more interesting feature in the economy of the hydræ is their mode of reproduction, which, in many respects, corresponds with what is witnessed among the simplest forms of the vegetable kingdom. The phenomena connected with this part of their history may be observed with the utmost facility, if a

few of the animals under consideration be kept for a day or two in a glass of their native water and sufficiently supplied with food. The first part of the process is the appearance of a small gelatinous bud, which is seen to sprout indiscriminately from some part of the external surface of the parent (fig. 13, *a*). The swelling thus formed rapidly enlarges (fig. 13, *b*), and, by degrees, assumes the appearance of a young hydra, shooting forth tentacula around its mouth, and soon resembling in every particular, except in size, the original being from which it grew. For some time, a portion of the food, caught and digested by the polyp, is seen to pass into the body of the offspring, which is at first entirely dependent upon its parent for support; but, when the tentacles of the newly-formed hydra become sufficiently developed, it begins to seize prey for itself, and contributes, in some degree, to the support of its mother. At length it is sufficiently matured to commence an independent existence; and then, the pedicle giving way whereby it had been hitherto attached, all connexion between the sprout and the parent stock at once ceases, and the young animal is cast off, to maintain itself by its own exertions.

Fig. 13.



But, perhaps, the most striking circumstance in the history of these remarkable creatures is their ex-

treme tenacity of life; for such is the simplicity of their structure, that any portion of their body obviously consists of the same component parts as any other portion, and is, therefore, quite adequate to perform the functions needful for its own existence independently of the rest, exactly in the same manner as a cutting from a plant can continue to live when separated from the tree that produced it. If, therefore, a hydra be cut in two, each half, having all the elements requisite to support its existence, will continue to live, and will even soon re-produce the deficient parts required to make a complete animal; nay, even if the creature be divided into several pieces, each fragment, as we are assured by Trembley, will continue to live, and, in time, develop all the wanting portions.

Such, indeed, is the facility with which this plant-like mode of re-production is effected, that monstrosities may be produced almost at the will of the experimenter. If a slit be made in the side of one of the little hydræ, the creature is not, apparently, injured by the incision; on the contrary, a bud immediately sprouts from the wounded part, and soon attains the form and dimensions of the original; so that, by a repetition of the process, two or three hydræ may be produced, forming one compound body, as in the examples represented in a preceding figure (fig. 11, *d*, *e*).

From the history of these simplest forms of animals let us, therefore, learn what wonderful properties are bestowed upon organized matter by the presence of a principle, which, in our ignorance, we call

vitality, or *life;* and if we thus find all our vaunted knowledge fail us, even at the very outset of our investigations, we shall, at least, be prepared to enter with due humility upon researches connected with more elaborately constructed beings.

CHAPTER IV.

ON THE CLASSIFICATION OF THE VARIOUS FORMS OF BEINGS COMPOSING THE ANIMAL KINGDOM.

In the preceding chapters, the reader has been made acquainted with the structure and attributes of those members of the organized creation that form, as it were, the transition between the vegetable kingdom and the extensive series of animals that now presents itself in long array before us, and, under innumerable diversities of shape and organization, bespeaks our earnest attention. It now remains for us, before we advance further with our inquiries concerning the history of any particular class of living beings, to take a general survey of the animal creation, with a view of separating it into certain grand and primary groups, each of which will, consecutively, come before us hereafter for more minute investigation.

It is difficult, however, to approach this part of our subject, stripping it, as we must do, of all unnecessary technicalities of expression and learned verbiage, without something like a smile at the inadequacy of the efforts, even of modern Naturalists, to accomplish this great and important task. We

remember reading an old analysis, undertaken by a chemist of former times, in which, after detailing the means employed in investigating the composition of some substance examined, for the purpose of detecting its composition, and telling us how he had succeeded in expelling from his crucibles certain quantities of *phlegm* and *phlogiston*, with other elements, strange to the chemistry of these days, he gravely terminates the inquiry by stating that nothing remained behind but *a quantity of dirt !*—a scrupulosity at which our chemists of the present time would, perhaps, be not a little startled. Unfortunately, in those great analyses of the animal world which have been attempted by different zoologists, it is astonishing to find what a great quantity of *dirt* has been invariably left unaccounted for—materials, unarranged and unclassified, thrown together into one chaotic heap—the dusthole of creation, into which every thing that is intractable, every thing that does not accommodate itself to their preconceived principles, is remorselessly cast.

We must, however, make use of something more than mere assertion in bringing this charge against modern naturalists; let us, therefore, take a cursory view of a few of the most celebrated systems that have, in turn, served for the guidance of scientific men, and test them with that strictness required by the importance of the subject.

Linnæus, the great founder of *system* in modern times, classified all the members of the animal kingdom under six grand divisions, as follows:—

1. Mammalia.
2. Birds.
3. Reptiles.
4. Fishes.
5. Insects.
6. Vermes, or Worms.

Of these six groups adopted by Linnæus, the four first, viz. Mammals, Birds, Reptiles, and Fishes, are evidently but members of one great primary division of creation, characterized by the possession of an internal living skeleton, composed of bone — the class Vertebrata of modern zoologists. The fifth group, Insects, included all creatures possessed of an external skeleton or hard skin, divided into articulated, that is, jointed segments — the *Insects, Spiders, Crustaceans, &c.:* while the sixth and last division, Vermes, embraced in its extensive grasp all the other members of the animal world that were neither Vertebrata nor insects: "Rubbish to be shot here" was legibly written over the very portal, and of course we are not surprised to find that the class Vermes of Linnæus was that province of the domain of Natural History that was most densely populated.

Cuvier, when it became his lot to criticise and remodel the labours of his great predecessor, Linnæus, was of course astonished to find so chaotic a group as that presented by the class Vermes, in which highly-organized animals, *Snails, Cuttlefishes, &c.* simply because they had no bony or articulated skeleton, were classed together with the lowest and simplest forms of creation, creatures most different and re-

mote, both in outward form and internal structure, being thus vaguely associated. This incongruity led to the next step effected in Zoology, namely, the separation of the class VERMES into two great divisions, the MOLLUSCA and the RADIATA; so that, in the Cuvierian system, we have all living beings arranged under four grand types:

1. VERTEBRATA.
2. MOLLUSCA.
3. ARTICULATA.
4. RADIATA.

But, unfortunately, the RADIATA of Cuvier, although they constitute but a part of the VERMES of Linnæus, are still liable to the objection originally urged against the entire group; for in the division RADIATA are thrown together animals the most dissimilar in their forms, in their structure, and in their habits.

Neither is it difficult to assign a satisfactory cause for the confusion that has thus all along prevailed in the classification of the animal world, seeing that zoologists have, continually, for want of knowing some primary character on which to base their systems, been content to adopt secondary and unimportant circumstances as the basis of every proposed arrangement, so that each has, in turn, failed, and been unable to stand the test of extensive observation.

Aristotle, for example, when he first began the great labour that has since been carried on with so much assiduity, was contented with dividing the

whole animal creation into two great sections. The one embracing all creatures that have blood, that is to say, red blood, and the other comprehending such animals as had, what he chose to call, *sanies* instead of blood; that is to say, animals having colourless blood. But obviously the mere colour of the blood, is too trivial a circumstance to be relied on in such an important case as this. Those animals that possess blood, according to Aristotle, correspond to the Vertebrata of modern Authors; but there are also worms that have red blood, and, consequently, were we to adopt the comparatively unimportant character, selected by Aristotle, we should be compelled to group together some of the humblest creatures, and the highest, and most perfect forms with which we are acquainted.

Linnæus thought that the heart, and the organs of circulation, were of primary importance in the animal economy; and, therefore, he appealed to these to guide him in his arrangement. But, if we take the structure of the heart as a basis of classification, we should have to put in juxta-position the fish, and the oyster; creatures must be approximated that are in every way remote from each other, and, consequently, the Linnæan system has failed for want of having a solid foundation whereon to stand.

Our great fellow-countryman, John Hunter, was fully sensible where the difficulty lay, and endeavoured with indefatigable industry and perseverance, to find some standard of classification which should be universally applicable. He tried, in succession, every

one of the great systems or functions of the animal economy, the organs appointed for the circulation of the blood, the apparatus of respiration, of digestion, of sensation; and endeavoured from any one of them to obtain some general principle that should be applicable as widely as was required. There is little doubt that John Hunter succeeded in getting, at least, an indistinct glimpse of the clue that would have served to guide him, but his life was too short to allow him thoroughly to avail himself of it.

Cuvier, from the extensive knowledge that he possessed of the internal structure, as well as of the outward forms of living animals; was enabled to combine together several of the most important features observable in their organization, and thus to model a system much more perfect than any that preceded him; but even Cuvier himself seems not to have been aware of the primary circumstance upon which his classification ought to have been established. On looking over the Cuvierian classes of the animal kingdom, it is easy to perceive that the very names by which they are designated are derived from trivial and comparatively unimportant circumstances; and, in consequence, are by no means adapted to all the animals that are ranged within the limits of the different classes to which they are respectively applied.

Among the Radiata of Cuvier, for example, animals (as the name would indicate) that radiate like flowers around a central axis, for that is the simple meaning of the word, we find forms grouped

together that cannot, by any stretch of the term, be said at all to participate in such a configuration.

The same remarks are equally applicable to the next great class, the ARTICULATA, which signifies animals possessed of an articulated external skeleton, the INSECTA of Linnæus. But how are we to call the leech, or the earthworm an articulated animal? They have their integument imperfectly divided into rings, it is true, and might by licence be classified under this term; but, obviously, the word ARTICULATA is too limited in its application to characterize the division to which it has been appropriated.

In like manner, the word MOLLUSCA only means that the creatures so designated have soft bodies, unsupported by an internal or external articulated framework, but this character is evidently insufficient to distinguish a class of animals so highly organized as the Mollusks, from countless other races, where a skeleton of any kind is equally deficient; and some higher characteristic must, of necessity, be pointed out before we can give a satisfactory title to this extensive division of animated nature.

Lastly, the term VERTEBRATA, which includes all animals possessing an internal bony or cartilaginous skeleton, cannot be regarded as entirely faultless, nevertheless, sanctioned as it is by age and general use, it will be, perhaps, better to adopt it than suggest an unnecessary change.

Seeing, therefore, that even the system of Cuvier is incomplete, and insufficient for the purpose we

have in view, it behoves us next to inquire after some other, and more decisive standard of arrangement, which fortunately now seems placed within our reach. It must be evident that, in order to obtain a guide to direct us that shall be universally applicable, we must first find out if there is any primary, or essential, portion of an animal to which all others are made subservient, and in conformity with the condition of which all the organs of the body must invariably be built up. The researches of modern Physiologists have, fortunately, left us in no doubt upon this important question. The essential part, the essence of any animal physiology, at once points out the nervous system, an apparatus composed of a peculiar material, called neurine, with which in all animals, so far as we know, the powers of sensation and volition are most intimately and inseparably connected. If, therefore, we could hope to ascertain, satisfactorily, the precise condition of this mysterious portion of the animal economy, in any given creature, we might reasonably expect to be able to predicate the consequent state of perfection of the muscles, of the limbs, of the senses, and, in fact, of every attribute conferred upon it.

To give an animal exalted powers and bodily capabilities, without giving it that nervous energy that should guide and regulate its movements would be absurd. Exalted senses, where there is no sensorium to appreciate the information derived from those senses, would be superfluous. Muscles, limbs, senses, and, in fact, general perfection of organization, must, therefore, be gradually and progressively

super-added, as the nervous system of animals rises from a lower to a higher condition; and, consequently, the faculties possessed by any creature must be estimated by the condition of this ruling portion of its economy. We shall now, therefore, proceed without further preface, to take the nervous system as a guide in investigating the classification of the animal world.

In all the forms of animal life described in the last chapter: in the *Sponges*, *Fungiæ*, and *Hydræ;* the reader will remember that there was no appearance of any complexity of internal structure, no distinction of muscles, or organs of any description: a mere parenchyma, or gelatinous film, constituted the entire substance of the body. In such animals as these, the highest powers of the microscope have not been able to detect anything like a nervous thread or an aggregation of nervous matter of any sort. But, as we cannot physiologically deny that sensation and perception are inseparably connected with nervous matter, we are compelled to admit that where animal sensation exists, *neurine* * must be present; still, as in these creatures we cannot detect its existence, either arranged in threads or collected into masses of any kind, we are driven to suppose that it is diffused in imperceptible molecules throughout the substance of their bodies, and hence such animals are termed

* *Neurine*, as already observed above, is the name given by modern writers, to the peculiar material that constitutes the nervous system. If agglomerated in masses, it forms *nervous ganglia* or *brains*, but when arranged in cords, or threads, of intercommunication, such cords or filaments are called *nerves*.

ACRITA *; because their nervous system is not distinguishable by our senses. We have been already shown in the history of the *hydra viridis*, that every circumstance connected with the economy of such animals, testifies to such a diffused condition of the nervous matter. Cut the *hydra* in two, and each part is found to be capable of independent existence, seeing that each part preserves its due share of the vital principle; or turn the *hydra* inside out, invert it like a glove, and the exterior can assume the functions of the interior: such is the simplicity of its organization.

The Division, ACRITA, of modern Zoologists, comprehending a large portion of the RADIATA of Cuvier, is, therefore, characterized by this grand circumstance, that they have no perceptible nerves nor brain, consequently they are deprived of muscles, or localised instruments of sensation, and present a type of organization peculiar to themselves. This Division of the animal creation embraces the following classes: —

ACRITA	SPONGES.
	POLYPS.
	INFUSORIAL ANIMALCULES.
	STERELMINTHA.
	ACALEPHŒ.

All the remaining RADIATA (Cuv.) are equally characterized by one grand circumstance; namely, that in all of them threads of nervous matter are

* *ακρινω, not to be discerned.*

found extending from one part of the body to another. Electric Telegraphs, if we may be allowed so to call them, that bring into communication all parts of the system. But, still there is no brain, or central mass of neurine, of sufficient importance to be regarded as a common sensorium, to which information derived from without, is specially conveyed, and, consequently, they cannot enjoy localised instruments of sensation. But, nevertheless, they possess muscles, because as soon as nerves exist muscular actions can be associated, and thus more energetic powers of locomotion begin to make their appearance. This division is, therefore, called NEMATONEURA, or THREAD-NERVED; * and contains:

Cœlelmintha.
Epizoa.
Bryozoa,
Rotifera.
Echinodermata.

In the third grand division of the animal creation, in addition to the filamentary nerves that ramify through the body, nervous *ganglia* or *brains* occur in the shape of minute nodules, or masses of *neurine*, arranged in a double row along the middle line of the body and forming, as it were, so many centres of life, to which information concerning external occurrences is speedily conveyed, and whence those mandates are issued whereby all the movements of the muscles are directed and controlled. These ganglia

* *νημα*, a thread,—*νευρον*, a nerve.

are distributed in pairs, along the whole length of the animal, and in exact conformity with this disposition of the nervous system is its outward configuration. The whole body is made up of a repetition of rings, or segments, such as are seen in the *leech*, the *centipede*, or the *insect*. While the brains, or nervous ganglia, remain of diminutive proportions, and, consequently, inadequate to correspond with highly-organized instruments of sense, or to preside over the actions of external limbs, such appendages cannot be expected to exist, and, accordingly, in the leech and the earthworm, the humblest forms of these annulose creatures, the more important senses and all external members are quite deficient.

But as the brain, or ruling centres of the nervous system become more largely developed, and, consequently, more perfect in their structure, limbs of progressively-increasing perfection are gradually appended to the two sides of the body, until at last, in the aerial insects, we have creatures endowed with wonderful strength and energy, and gifted with senses and attributes of a very elevated character. The third great division of living beings is, therefore, at once distinguishable by this grand character, that all the individuals composing it possess numerous brains, or nervous ganglia, arranged in two parallel series; and as the different pairs of ganglia almost precisely represent each other, the whole group is well distinguished by the term HOMOGANGLIATA.* To this division belong

* Ομος, similar; γανγλιον, a ganglion.

ANNELIDANS .	*Leech, Earthworm, &c.*
MYRIAPODA .	*Millepede, &c.*
INSECTA . .	*Fly, Butterfly, &c.*
ARACHNIDA .	*Scorpion, Spider, &c.*
CRUSTACEA .	*Shrimp, Lobster, Crab, &c.*

The FOURTH DIVISION, the MOLLUSCA of Cuvier, is equally to be recognised by the condition of the nervous system. In the Mollusca, as in the Homogangliate division of animals, there are several brains, or nervous centres, distributed through the body, but here they are not symmetrically arranged in a double longitudinal series, but disseminated here and there in different portions of the system. The form of these animals presents, moreover, a want of symmetry, corresponding to the unsymmetrical disposition of the nervous masses; and the whole series forms a group perfectly natural and distinct, on which modern zoologists have bestowed the name of HETEROGANGLIATA.* Such are—

CIRRHOPODA . .	*Barnacles, &c.*
BRACHYOPODA .	*Terebratula, &c.*
TUNICATA . . .	*Ascidians, &c.*
CONCHIFERA . .	*Oyster, Mussel, &c.*
GASTEROPODA .	*Snail, Whelk, &c.*
PTEROPODA . .	*Clio, Borealis, &c.*
CEPHALOPODA . .	*Cuttle-fish, Nautilus, &c.*

Lastly, we have, the VERTEBRAL DIVISION, to which Man himself belongs—animals characterized

* Ετερος, dissimilar; γανγλιον, a brain.

by the possession of an internal, living, bony or cartilaginous skeleton, and having the principal centres of the nervous system once more arranged in parallel ganglia, but enclosed in a skull and vertebral column. This division, which includes the highest and most intelligent races of animals, has received, by universal consent, the name of VERTEBRATA, and embraces the important classes of—

PISCES . .	*Fishes.*
REPTILIA . .	*Reptiles.*
AVES . .	*Birds.*
MAMMALIA . .	*Whales and Mammiferous Quadrupeds.*

We shall, therefore, in the following pages, proceed, without further comment, to classify all the members of the animal kingdom under five great divisions, of which one extensive series is characterised by having no nervous system whatever distinguishable by our senses; a second by having nerves like threads, but without ganglia, or brains of any magnitude; a third, possessed of brains, symmetrically arranged in a double series along the body, and having an external articulated skeleton; a fourth, with the nervous ganglia disseminated through the system without any symmetry of arrangement; and the fifth, distinguished by the presence of an internal bony or cartilaginous framework and the possession of an encephalon and spinal cord, or spinal marrow, as it is generally designated.

Here, however, we must beg our non-scientific

readers not to be prematurely alarmed at the formidable array of high-sounding words, which, being enlisted in the service of science, we have been obliged to parade before them in the general review of the animal creation we have made in this chapter. Greek and Roman as they are, and apparently invincible when thus joined in phalanx, we are now about to attack them singly.

CHAPTER V.

ACRITA.—POLYPS.

We have already, in a preceding chapter, detailed at length the history of some of the Acrita, the Sponges, Fungiæ, &c. and related the wonderful history of the *hydra*, one of the simplest beings belonging to the animal creation — a stomach, and nothing but a stomach, nevertheless a stomach capable of locomotion, endowed with sensation, and, moreover, able to feed itself in a manner that must appear truly miraculous to any one who may witness the process we have described. Our admiration must now no longer be limited to the contemplation of those twilight forms of life, but we must here prepare ourselves to meet with still more strange and widely-different existences. The next creatures that present themselves to our notice are animals provided with hundreds of mouths and hundreds of stomachs, all of which minister to the nutrition of one common body. The *Lobularia*, a zoophyte belonging to the family of polyps, named Alcyonidæ,* is of this description, and is represented in the appended figure (fig. 14). These compound polyps, as they are called, are met with abundantly on the sea-shores of our own country, and, to the

* Family of Alcyons.

uninstructed, would appear to be merely shapeless masses of fleshy substance that could not be suspected to possess life at all; for if the sea-side visitor chooses to confer upon them the name of "dead-men's fingers," from their supposed resemblance to such uninviting objects of contemplation, that is, generally, all the notice bestowed upon them.

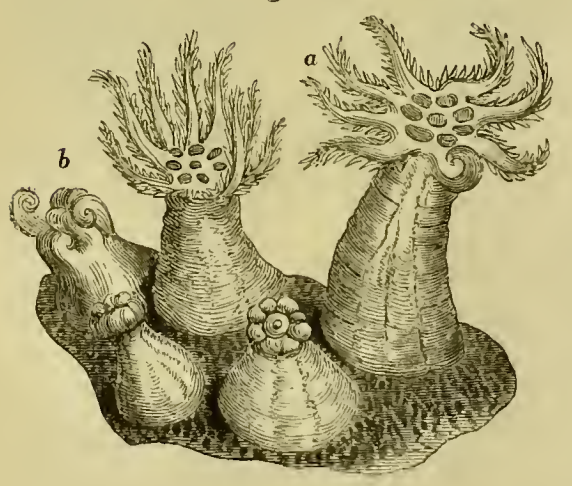
Fig. 14.

But let one of these lumps of jelly be placed in a glass filled with its native element, the sea-water, and watch it there; then if the spectacle that it offers does not excite the attention of the observer, we apprehend there is nothing in creation that will. The gelatinous mass gradually swells, appears to be imbibing the water in which it is immersed, and, as it dilates to a larger and still larger size, assumes a transparency that it did not possess before. When fully expanded, little pits or cells appear upon its surface, and from each of these issues forth a living flower,—for such it seems in shape,—a simple polyp, which, gradually expanding till it has attained its full development, reveals itself to be a *hydra*, fishing

for surrounding prey by means of petal-like tentacula placed around its mouth. The food thus obtained, having been conveyed into the stomach of the polyp that caught it, and digested there, is absorbed into the general mass of the common body of the *alcyon*, which in this way derives its nutriment from the numerous sources of supply distributed over its surface.

On examining the structure of the *alcyon* more minutely, we should find that the individual polyps studding the surface of the common mass, a few of which are represented in the adjoined figure (fig. 15), in different states of extension, are each of them, when fully expanded, furnished with eight pinnated arms (*a*) that surround the mouth, and are calculated to seize food in the same way as those of the hydræ, and convey it into an opening that leads to the stomach, situated in the centre of the radiating disc. The substance of the common body from which these polyps spring is soft and fleshy, but permeated with large fibrous canals; its whole appearance, in fact, reminding the comparative anatomist of the fleshy sponges from which, in texture at least, it does not appear to differ very widely.

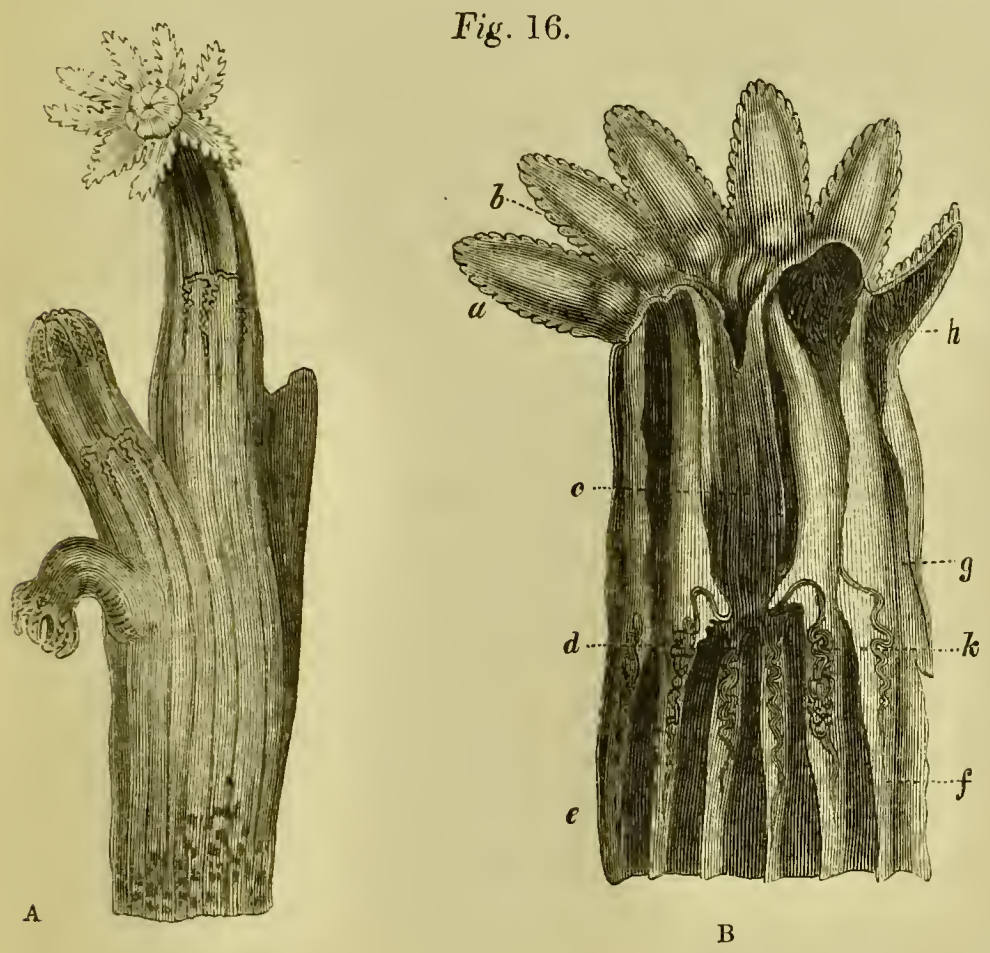
Fig. 15.



In fig. 16 (A. B.) the communication between the polyps of the alcyonidæ and the common body is deli-

neated, the roots of the flower-like animals being denuded and traced into the common mass; while in the second (fig. B), the interior of one of the

Fig. 16.



polyps is represented, showing the structure of the tentacles (*a*, *b*); of the stomach (*c*); of the cavity of the body (*g*, *h*) divided into compartments by numerous membranous partitions (*f*), and also a few convoluted tubes (*d*, *k*), wherein the germs of a succeeding race are doubtless formed. But the mechanism of all these parts will be better understood when we have examined the *Actiniæ* and other polyps of a higher description, where the internal structure of the body is more elaborately developed.

Our next subject of inquiry must be concerning the

phenomena presented by these *Alcyonidæ* whilst alive, premising that the observations we shall have to make upon this subject are almost equally applicable to the entire series of the polyp-bearing zoophytes, hereafter to be described. We have already said that these animals possess no nerves whereby rapid intercommunication between remote portions of their structure can be effected, and, this being the case, every molecule or particle of the creature must feel and act for itself, and, to a great extent, independently of the surrounding parts. If a single flower be touched, that flower shrinks from the contact, but the neighbouring polyps appear to have no alarm, and do not participate in the movement. If the side of the gelatinous mass be punctured, the part irritated contracts, but the rest of the common body of the polypary seems unconscious of the violence offered. When the shrinking has once commenced, however, it is communicated from particle to particle, until, at last, the whole mass consents in the movement, but it is slowly that the contraction pervades the more remote portions of the animal. But if the converse of this experiment be tried, and the jar in which a fully-expanded *alcyon* is contained be forcibly struck, then every particle of the creature feeling the impulse at the same instant, the polyps simultaneously shrink; all the flowers are withdrawn; the whole body becomes contracted and opaque, and the animal would scarcely be recognised in this condition for the beautiful and elaborate structure that it really is.

These animals, moreover, secrete in the interior of the fleshy substance of their bodies earthy particles,

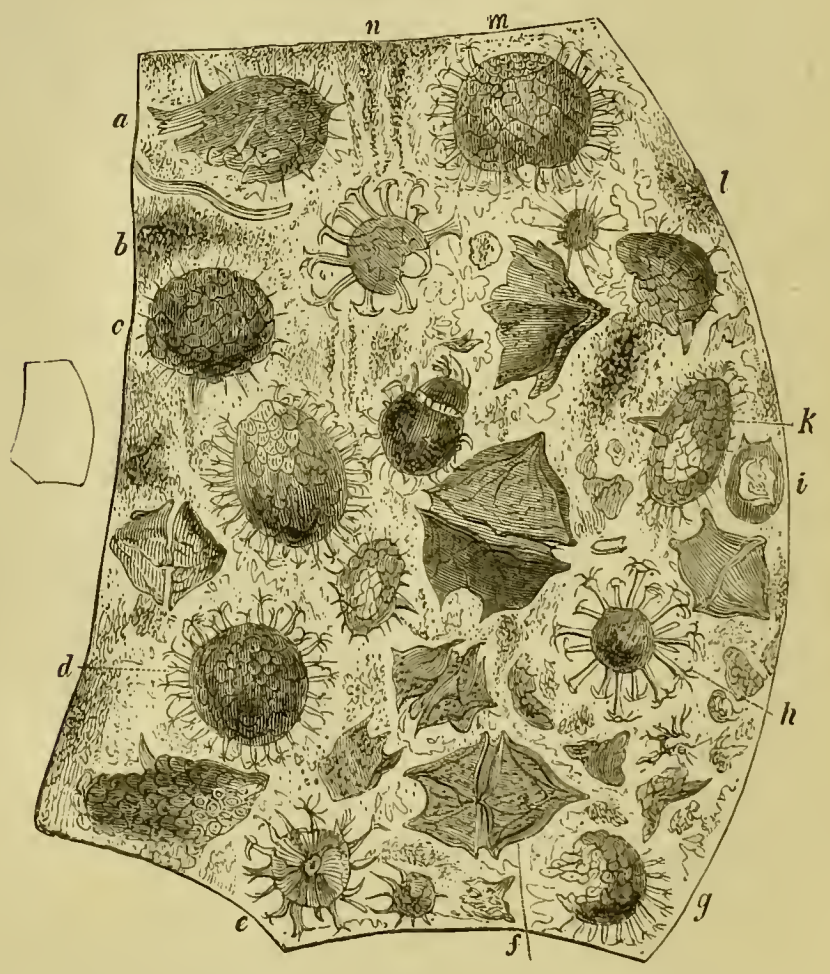
which form a kind of rudimentary framework that assists in supporting the gelatinous mass, in a manner very nearly comparable to what we have already seen in the SPONGES, properly so called; the earthy matter being disseminated so as to give a gritty sensation when a knife is used to cut one of these creatures. In texture, therefore, the body of the *alcyon* very nearly approximates that of the *sponge;* and this circumstance is of the utmost importance both to the naturalist and the geologist, inasmuch as it shows to the one the near affinity that exists between these two tribes, and explains to the other circumstances that would not otherwise be easily intelligible.

That sponges become converted into flints by the constant percolation of water through their soft bodies we have proved in a preceding chapter, and here, in the alcyonidæ, we at once perceive another source whence flinty masses may be produced in a precisely similar manner; the earthy molecules of the sponge-like *alcyonium*, forming nuclei, around which siliceous atoms accumulate precisely as in the case of the sponges themselves, which, indeed, after death, the central mass of these compound polyps must very closely resemble.

This view of the manner in which flints are produced has been not a little confirmed by recent microscopical investigations, proving flints to contain an immense number of infusorial animalculæ—animalculæ such as now exist abundantly in fresh and in salt water; nay, so numerously are these microscopic remains met with, that some flints were at one time thought to be entirely composed of an aggregation of

the shells of minute creatures. It is not, however, necessary to have recourse to such an hypothesis as this, seeing that both the Sponges and the Alcyonidæ, after death, must be filled with myriads of the animalcules that abound in water wherein they are immersed; and if in the section of a flint the remains of these animalcules are found, it simply arises from the circumstance that the Sponge or Alcyon was full of them after vital action ceased within it.

Fig. 17.



The appended figure (fig. 17), represents a thin slice of a flint, in which such remains were very abundantly met with. The real size of the piece is

shown in outline upon the left-hand side of the principal figure, and in the magnified view numerous forms of the enclosed animalcules (*a, b, c, d, e, f, g, h, i, k, l, m, n, &c.*) are represented; but any account of these last we must defer to a subsequent chapter, when, doubtless, the reader will be enabled to recognise some of the living representatives of the fossilized relics here depicted.

MADREPORIDÆ.—When it becomes necessary to increase the size of animals that, in all essential points, are allied to the *alcyons* above-described, and to dilate them to far more extended dimensions, it is evident that, in order to accomplish this, a framework must be given of sufficient strength and stability to keep the whole in a definite and proper form, in order to prevent the soft living substance from being crushed or distorted by its own weight. Such a framework has accordingly been provided, and admirable indeed is its construction. Those beautiful rocky masses, for such they appear to be to the vulgar eye, called MADREPORES, which, branching into countless varieties of arborescent forms, are abundantly met with in the ocean, and so frequently ornament the cabinets of the curious, are merely fabrics constructed by compound polyps, similar to those last noticed, and owe their growth to the accumulation of earthy particles deposited within a fleshy substance that is nourished by countless polyps, more or less resembling *hydræ*, diffused over all its external surface. Take, for example, the well-known madrepore delineated in the next page (fig. 18), the branches of which are, even when superficially

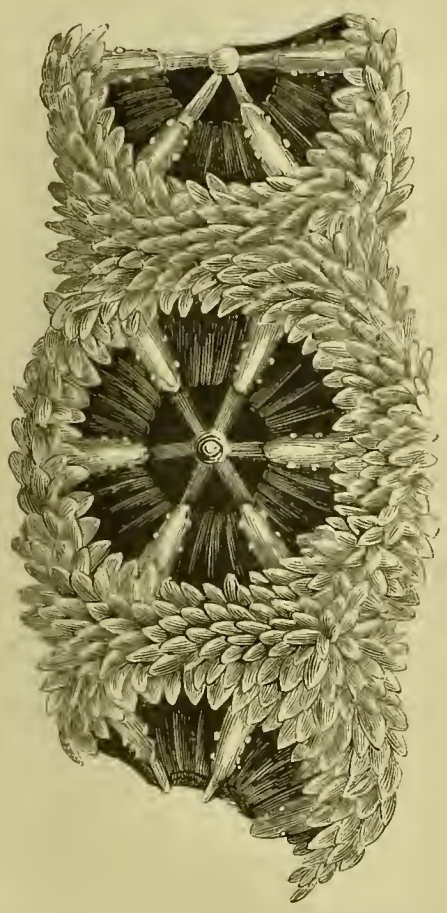
viewed, remarkable for their elegant appearance, and, indeed, upon closer inspection, the admiration excited by the whole fabric is not likely to be dete-

Fig. 18.

riorated. Every one of the branchy stems of the madrepore is seen, upon a cursory survey, to be covered with multitudes of minute pits or depressions, although these, from the smallness of their size, are scarcely visible to an inattentive observer. Examined with a magnifying-glass, however, each of these multitudinous orifices is found to be a cell of beautiful construction, equally remarkable for the mathematical regularity with which it is formed and the exquisite fineness of the materials

composing it, as doubtless the reader will acknowledge, on inspecting the drawing here given of one or two of the cells (fig. 19) represented upon an enlarged scale. But if the dried skeletons be thus admirably constructed, surely the madrepores, when in a living state, must have been still more worthy of our contemplation. In this condition, it would be found that every part of the surface of each stem is covered over with a living gelatinous crust, not a mere film, unprovided with any mouth, as in the case of the fungiæ, but furnished with millions of little polyps, that can emerge from the countless apertures visible all over the exterior of the polypary (fig. 18), every one of which is organized upon the same principles as those we have already met with in the alcyonidæ, described in a preceding page (*vide fig.* 16), and equally efficient in procuring and digesting nourishment for the support of the general body.

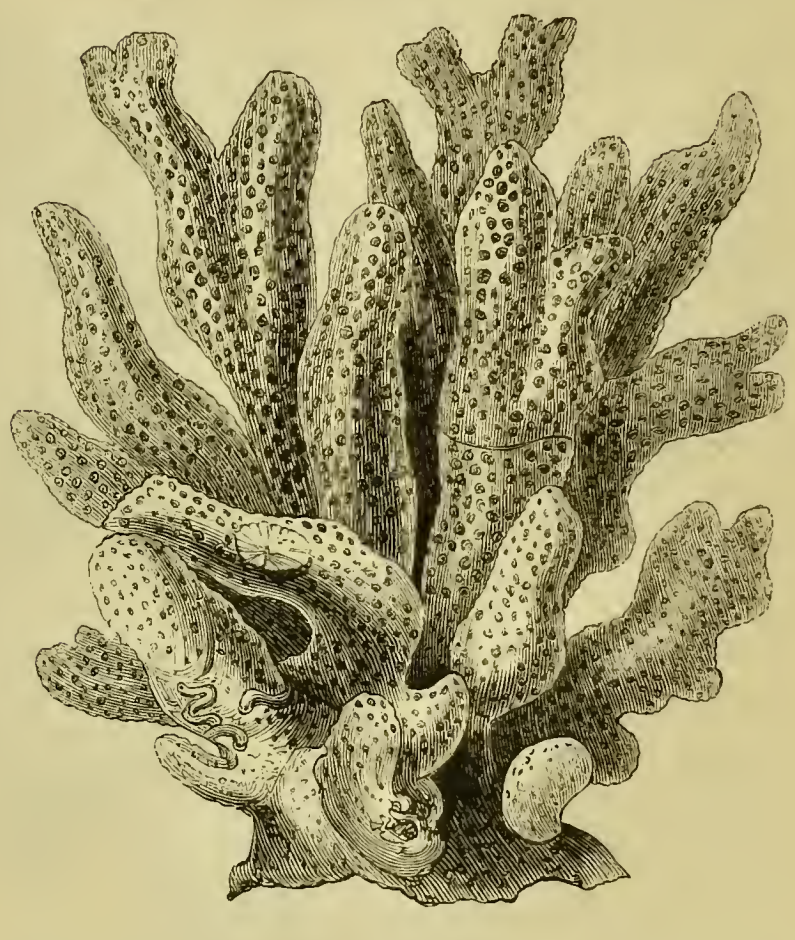
Fig. 19.



It is not within our province here to attempt to lay before the reader an enumeration even of the principal variations in form presented by these admirably-constructed, though humble, members of the animal creation. Some of their stems branch

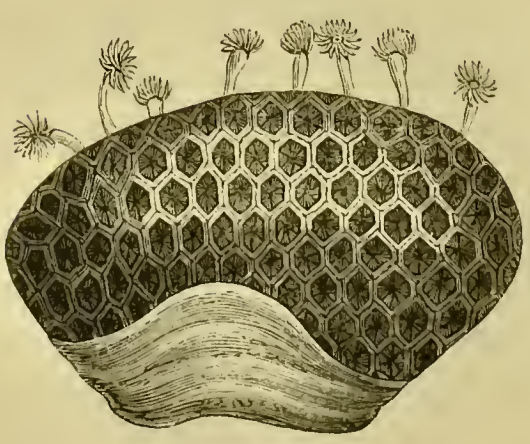
out like the horns of deer, or assume the appearance of broad plates or rounded masses; but, whatever

Fig. 20.



may be their shape, the living part invests the whole exterior of the body, and from every delicately-laminated cell the hungry polyps, when in an active state, are protruded, in search of prey, as shown in the adjoining figure (fig. 21), where a few of them are represented busily engaged in catching

Fig. 21.



food. We may well suppose that it would be a beautiful and a wonderful sight, could we contemplate, in its native locality, a mass of madrepore, even of the dimensions here delineated, covered with its living investment, and feeding itself by the agency of countless mouths, each endowed with separate life and distinct power of action; slowly precipitating from the surrounding sea cretaceous particles wherewith to build its stony fabric; gradually constructing, layer by layer, and stratum upon stratum, the elaborately-formed polypary, or skeleton peculiar to its species. But let us not circumscribe our ideas within these petty limits: rather let us give our fancy free scope; for widely indeed must we stretch our imagination if we are at all to appreciate the importance of the class of animals we are now considering. Let us endeavour to picture to ourselves an extent of the bed of the ocean, spacious as these realms that we inhabit, carpeted with living plants; every blade of grass and every flower instinct with life, and all the vast expanse busily engaged in deriving from the surrounding water materials for subsistence: let us consider that, from age to age, the wide-spread scene is building up, by constant precipitation from the sea, a rocky territory, co-extensive with itself, and then we shall perceive that, in the course of time, even these almost unknown members of the animal creation may perform achievements at which the boldest mind is startled when it comes to survey what they have accomplished. Gradually, the accumulating pile rises towards the surface of the sea, and, at length, after the lapse of

ages, portions of the rocky fabric show themselves above the waves. Here further growth is checked; the polyps cannot live beyond the point where water freely reaches them, from whence they may derive the means of nutriment, and thus they perish. Still the structure reared becomes a nucleus round which materials may be gathered; and the multitudes of zoophytes, still living and still acting, swell its bulk, and add continually materials near the edge of the increasing reef. The storm tears up the dirt and sand and sea-weed from the deep to heap it on the summit of the nascent island. Animal and vegetable substances are slowly, but constantly, thrown upon the new-formed rock, and, being entangled among the coral, perish. These decay, and, by decomposition, form a mould fit to support the growth of plants. Seeds arrive, brought there by accident, or by the visits of migrating birds, which, soon taking root, become the germs of future vegetation, till, at length, islands, both broad and long, and richly wooded, stretch where all was once deep sea. Man comes at last, and with him fit inhabitants to people these new countries — regions snatched from ocean by the silent toil of beings such as those we have described.

Turn we, however, nearer home. Our native mountains, and our lime-stone rocks, tell us of agencies not less stupendous. Do we not find, imbedded in the rugged cliffs, and high above the level of the sea, countless remains of madrepores conformable, in every circumstance, to those at present in existence, and to which the naturalist gives names, and classifies their skeletons as easily as those of recent

times, although now buried in the solid stone, of which they form a part, and found quite in the centre of a country such as ours? Here again we must not judge the grand phenomena of Nature's operations by the low and puny standard of our usual thoughts; no ordinary figures serve to paint convulsions so terrific and sublime as those that piled the treasures of the deep upon our highest hills. Fancy beneath the ocean's bed, encrusted thick with ponderous strata of these madrepores, that there exist volcanic fires; huge furnaces that rage in Ætna and Vesuvius, and reach, perhaps, beneath the wide Atlantic, to the mighty chain of burning mountains that extends throughout the Andes—ay, and far beyond!

Some accident, or earthquake, opens a wide chasm in the bottom of the deep; the sea itself pours through the yawning fissure, and leaps down into the fiery gulf; the imprisoned steam produced by such a dread catastrophe, putting its Titan shoulders to the vault above, heaves up the vast incumbent roof, rocks, corals, shells and all.

"Mountains huge upheave their broad, bare backs into the clouds"

soon to become centres of realms and empires, though, at first, built at the bottom of the sea by these poor zoophytes.

Corallidæ. Other tribes of cortical polyps, that is, of such compound zoophytes as have their living crust placed upon the exterior of that skeleton which forms the basis and support of the entire fabric, assume a more decidedly ramose and branched

appearance than those called madrepores, nor does the surface of their dried polypary present the pores, or star-like cells, that were so characteristic of the group last described.

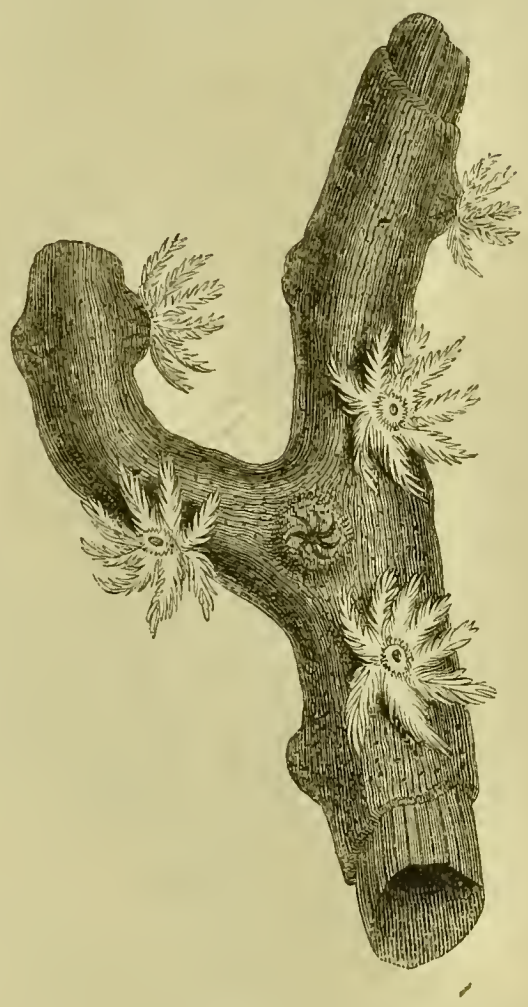
Of these corals, as they are named, we select for particular description the well-known *Corallium rubrum*, the polypary of which is that beautiful and valuable substance called, *par excellence*, *coral*—an article, that, from its extreme density and susceptibility of a high polish, is so much esteemed for the manufacture of ornaments.

The coral in question is met with in considerable abundance in the Mediterranean, where important fisheries are established in order to obtain it; although, from the depth at which it grows, and the difficulty of detaching it from the rocky reefs where it locates itself, the trade of a coral-fisher is somewhat precarious.

If examined in the living state, it will, at once, be found that coral, both in its mode of growth and from the manner in which its polypary is constructed, is nearly allied to the madrepore races. Every branch of the stony axis is crusted over with a thick coating of a fleshy substance, and from the surface of this living crust, numerous polyps, similar in conformation to those of the *alcyons*, extend themselves on all sides in search of food (fig. 21). In proportion as the living part of the Corallium expands and grows, it continually deposits in its interior the calcareous matter that it derives from the ocean, which is frequently coloured with a rich red tinge, laying on additional particles, layer

by layer, like the coats of an onion, around the outer surface of its branched skeleton, and thus increasing the diameter of the internal polypary until, at length, after the lapse of years, it arrives at those dimensions that make it serviceable to the manufacturer. On stripping off the living bark that secretes and forms the stony stem within, no cells for the lodgment of the polyps are perceptible upon the latter; these hydraform mouths are contained in the thick crust itself, which, instead of being quite soft and gelatinous, is now mixed up with cretaceous granules, and thus becomes sufficiently firm to give shelter to the polyps that feed it.

Fig. 21.



The polypary of the *coral* is short and stunted in its branches, and, these being of stony hardness, it is well able to withstand the most violent impetus of the waves that assail it. But if it becomes necessary to elongate the stems of corals similarly constructed, to make them of considerable length, but at the same time extremely slender,

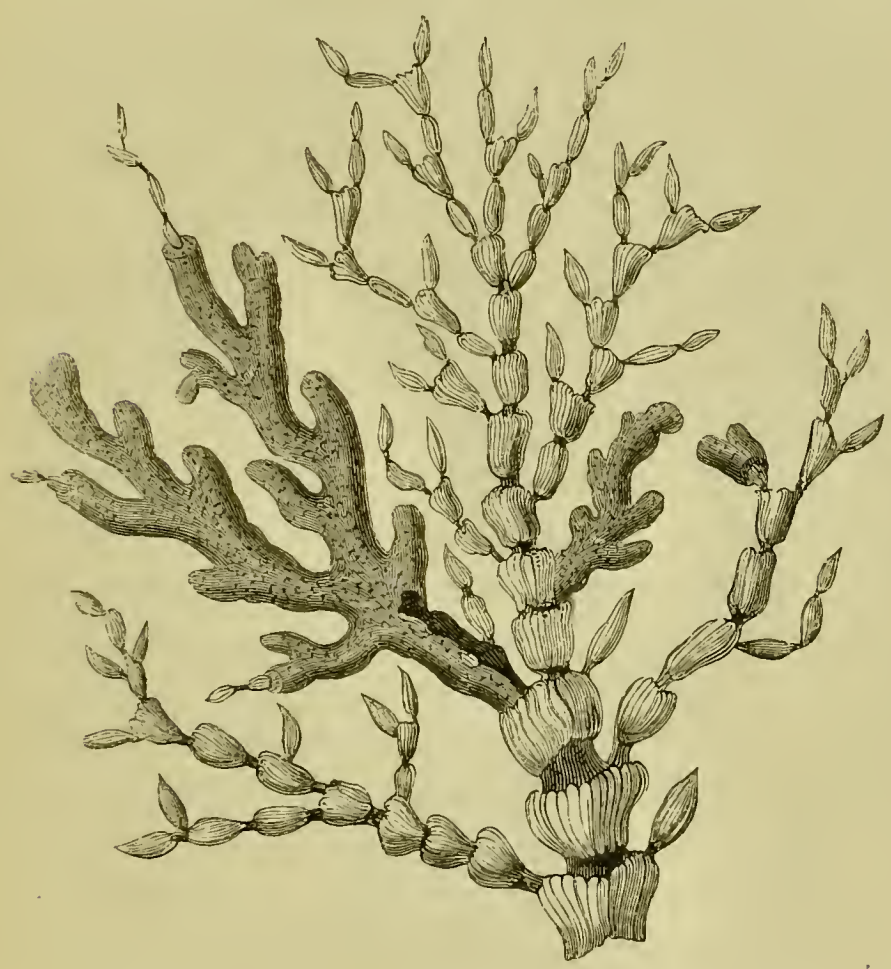
the stony substance of the coral we have been describing, hard as it is, would be far too brittle to sustain the violence of an agitated sea; and, under such circumstances, some modification in the structure of the skeleton must, necessarily, be adopted in order to preserve the polypary from being broken into fragments and destroyed by the force of the waves. This danger has, however, been obviated by a very beautiful and simple mechanism. It is not absolutely necessary that the skeletons of cortical polyps should be constructed of stone, or, in other words, be composed entirely of carbonate of lime: for, however ignorant we may be concerning the causes upon which the different secretions depend, the living crust that covers many species is endowed with the power of selecting from the ocean materials that will bend: instead of chalk, horn is made use of; and with this many zoophytes construct a framework which, being flexible in every direction, bows before the passing wave and rises again uninjured, where a more fragile polypary would inevitably be crushed.

Of such description are the *Gorgoniæ*, easily distinguishable by their horny and ramose stems; upon which, when dried, the cortex remains solidified, as it were, by the quantity of calcareous substance deposited in its texture, still exhibiting the colours that it presented during life—red, orange, or purple tints of considerable brilliancy.

Besides the proper *coral*, which secretes stone, and the *gorgoniæ*, that construct horny branches, it is found that some genera combine the two materials in

the fabrication of their framework. In the *Isis hippuris*, for example, this combination has been adopted and, obviously, with a view to give flexibility to the polypary so organized. In this species the skeleton (fig. 22) is made up of alternate joints, one

Fig. 22.



segment being of calcareous substance and the next of horn, so that, by a slight modification in the construction of the central axis, the needful power of bending is obtained.

Beautiful and exquisitely designed as the dried *Isis hippuris* must appear to the most unobservant, its beauty while in the living condition must have

been infinitely more striking. The thick and coloured crust investing every bough, (whereof a portion only has been left in the figure,) when clustered with living polyps all at work, active and hungry, fishing to supply the general substance of the zoophyte, form indeed a spectacle which must be left to the imagination of the reader.

Plant-like as are the ramifications of the compound zoophytes we have been discussing, we need not further indicate how far remote they are from vegetables both in their structure and economy; the roots that fix them to the rocks are but expansions giving firmer hold upon the basis of support, and not, in any way, organs to furnish nutriment; the living flesh encrusting the whole skeleton is fed by myriad stomachs, quite sufficient to provide materials for its sustenance, and thus it grows, depositing within its substance the support peculiar to its species.

Pennatulidæ. The compound polyps, hitherto described, are fixed immoveably—cemented, as it were—unto the rock whereon they rest: but there are some, allied in structure, which, although they have a central stony axis and a living crust encasing their exterior, studded thick with active polyps, are not fastened down to one locality, but free and, possibly, able to change their place, either at will or when removed by accident. Many are found upon our coast, and from their general aspect they are named "Sea-pens" (*Pennatulæ*). In outward form, they strikingly resemble quills of which one end, the barrel, is denuded, but the rest covered with living flesh. The stem contains a long

and stony axis, and, on either side, the feather of the quill is formed by moveable appendages, from which the polyps issue. The naked part is generally found implanted in the sand or mud of shallow bays, but unattached to any solid substance. Some assert, and Cuvier seems to advocate the same opinion, that the fleshy portions move in concert, and thus row themselves from place to place; but this is scarcely credible in creatures so devoid of senses and so humble in the scale of animal existence. Various species are seen on different shores; some without lateral barbs, some kidney-shaped, with polyps on a flattened disc, some rounded or cylindrical, and many shine with brilliant phosphorescence in the night, a property they share with countless other inmates of the sea.

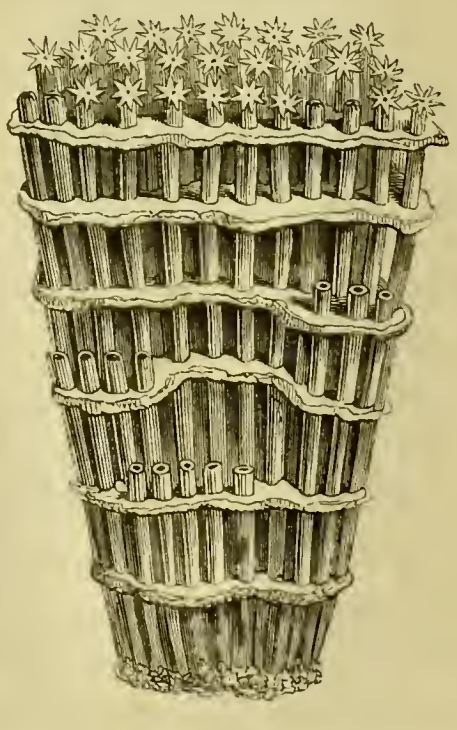
TUBULARIDÆ. All the preceding tribes of compound polyps have a central part, or body, studded upon its surface with the mouths that furnish nutriment and feed the general mass. We now arrive at animals similar, in form and general structure, as regards their flower-like mouth and mode of seizing prey, to those we have described, but widely different in respect to the arrangement of their skeleton. In the next race the hard support is placed on the exterior of the living flesh, encasing it, as in a tube; from one extremity of which the polyp is protruded when in search of food, or it retires within when danger threatens. TUBULAR POLYPS, then, for so they are appropriately named, have their living portion resident *within*, and not *external to* their skeleton.

The *Tubipora musica* is one of the most elegant

and striking examples of this kind of zoophyte, and the beautiful polypary constructed by it, is not unfrequently met with, in the cabinets of the collector of natural objects. It consists of successive stages of cylindrical tubes of a rich crimson colour, placed one above another, until the whole fabric is not inaptly compared to the rows of pipes in an organ, whence the origin of its name.

The tubes placed upon the upper stage are inhabited by the most recent race of polyps, the occupants of those below having successively perished as fresh generations accumulated above them. The general appearance of the *tubipora* will, however, be

Fig. 23.

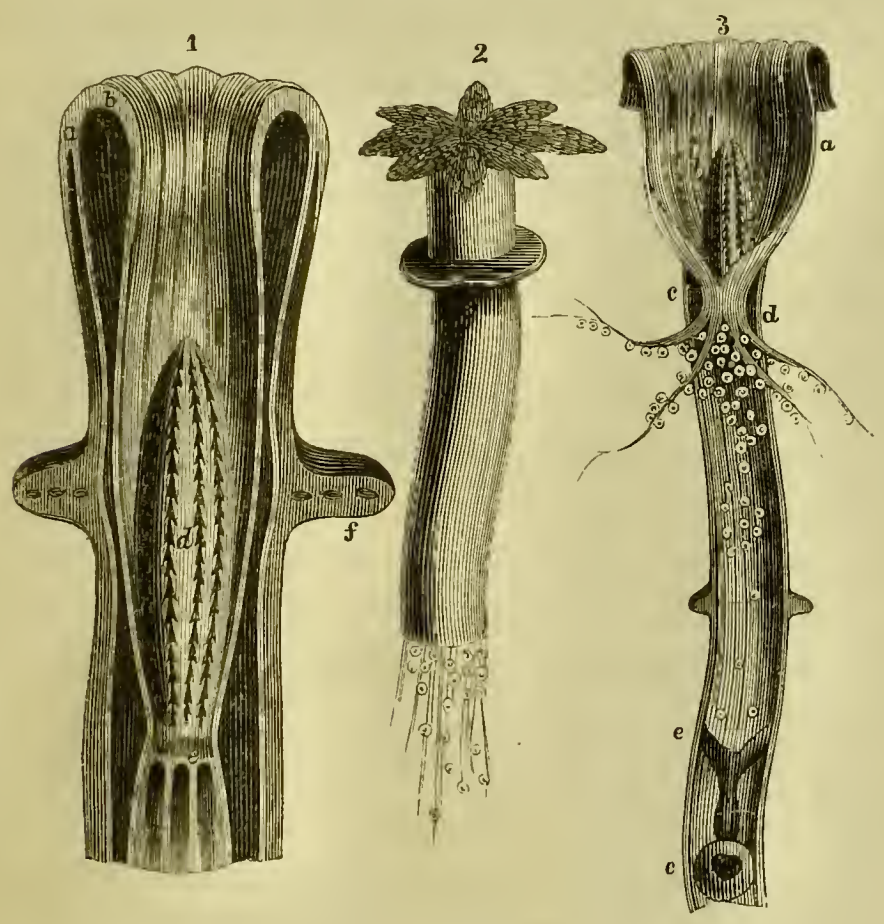


more readily understood by a glance at the figure given above (fig. 23), than from any lengthened description, and we will, therefore, now proceed, confin-

ing our attention to a single tube and its contents, to describe the structure of the being placed within, its mode of reproduction, and the way in which the different tiers are formed.

A tube with its expanded polyp actively employed is seen in (fig. 24, 2). The tentacles spread out around the mouth are finely granulated, and their colour, a pure green, richly surmounts the crimson sheath from whence they are protruded. When with-

Fig. 24.



drawn into their shelly case the tentacles are closely folded like a bud (fig. 24, 3, *b*) and lodged within the folds of a contractile membrane (*a*) that is continuous

with the margin of the tube (fig. 24, 1, *a*, *b*), and constitutes, in fact, the mechanism whereby the creature is protruded; for, being implanted all around the base of the included polyp (*e*), its contraction brings the flower-like mouth towards the opening of the cell, and when everted, as it doubtless must become, to ensure the full protrusion of the bud, the latter opens and displays its tentacles, as seen in fig. 24, 2.

Beneath the body of the polyp, and appended thereunto, are several delicate membranous filaments (fig. 24, 3, *d*) contained within the tube, whereon the germs of future progeny are formed, resembling strings of delicate beads, transparent globules of gelatinous consistence. These, as is supposed, remain imprisoned while the parent lives; but on the death of their original they issue forth, and, falling on the stage last built, they there become attached, and soon expand to form another generation of tubes and polyps like to those from whence they emanated. The manner of their growth, and the formation of the tubes enclosing them, are subjects of deep interest, and bear upon a question of no small importance in relation to the nature and condition of the skeletons or polyparies of zoophytes. The generality of modern writers, and many physiologists of distinguished eminence, still continue to assert, that the hard calcareous or horny supports of the different varieties of polyps are extraneous substances, exuded in the first place from the surface of the body and, afterwards, being moulded into shape, either upon or beneath the living flesh that secreted them, are no longer under the control of vital influences, but,

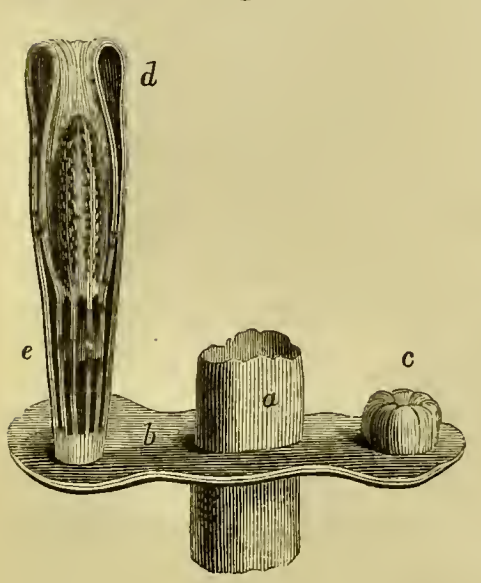
having been cast off from the body, are as dead and incapable of being acted upon by the animal portion of the zoophyte, as the rock upon which they are fixed. A very little reflection, or, at least, a candid examination of the facts that court our notice, connected with this dogma, will, doubtless, lead the reader to more correct views upon the subject, and prove that the calcareous, or earthy matter, that gives hardness to a polypary is deposited, not external to, but, in the interior of the living substance of the zoophyte, and, moreover, that, after its deposition, it is still subject to the control of the soft parts connected with its formation. We shall, hereafter, have abundant opportunity to accumulate proofs of these important positions; but the first we must adduce is derived from what is narrated concerning the developement of the *tubipora* and the progressive growth of its successive ranks of stony cells.

No sooner does one of the numerous gelatinous germs, alluded to above, escape from the tube that encased the original polyp, than it spreads out upon the uppermost horizontal stage, which connected the tubes of the last generation, and, becoming firmly attached, swells into a kind of cylindrical cushion (fig. 25, *c*), which, as yet, presents no trace either of the future polyp or of the shell that is to enclose it.

Soon, however, it elongates itself and extends upwards into a tubular form, the inferior portion, originally soft, becomes slowly calcified or hardened by the interstitial deposit of earthy matter in its very substance; the base thus assuming a stony density, while the upper and growing part of the

tube, still continues soft and fleshy. It is not until the height of the fabric has advanced considerably, that the polyp and its appendages are seen within, as represented in fig. 25, *d*; but, even at this period, while the lower part of the tube (*e*) is hard and calcareous, the upper portion (*d*) remains fleshy and contractile. But how is the horizontal stage constructed that is to unite and consolidate all the tubes placed on this story of the edifice, forming at the same time the floor upon which the next generation is to be deposited?

Fig. 25.



This part of the process is exhibited in fig. 24, 1. The upper extremity of the tube being as yet soft, and having arrived at a certain altitude, spreads out horizontally into a disc-like expansion (*f*), which, at the period of its formation, is, of course, at the top of the tube. By some unknown law, or instinct, all the growing zoophytes throw out this fleshy disc simultaneously, and at precisely the same height above the stage, so that the margins of contiguous discs coalesce, and, becoming fused together, constitute one plain, unbroken surface, which is soon calcified and hardened into stone by the same process as the tubes themselves, and thus the stage is formed and perfected. This part accomplished the work again proceeds, the tube once more

ascends and gains its perfect height; calcification ceases, and at this point the tube-secreting membrane (fig. 24, *a*) is found continuous with the inflected portion (*b*) that goes to be implanted round the polyp's base at *c*.

The *Tubularia indivisa;* a zoophyte by no means unfrequently met with upon our own shores, is an illustration of another form belonging to the group under consideration. The body of this creature inhabits the interior of a long, horny, and transparent tube, from the extremity of which the polyp is protruded. The polyp itself is furnished with two circlets of tentacula, one placed around the mouth, the other at a little distance lower down. These tentacles are all acutely sensible and grasp whatever objects come within their reach, conveying them into the stomach, where they are dissolved and melted down for food.

Of the manner in which nutriment is distributed through the soft and semi-gelatinous textures of the animals, described in former pages, little or nothing is at present known. But in these tubular genera there exists something analogous to circulation, a perpetual flow of particles within them, destined, apparently, to diffuse the nutritive materials. Currents are perceived through the transparent shell conveying globules up and down in different directions, by some means we cannot understand. The whole phenomenon, indeed, resembles what is seen in some transparent vegetables, and, perhaps, the difference between the two, as relates to this circumstance, is not wide.

Sertularidæ. We next come to the considera-

tion of a numerous race of compound polyps having skeletons so branched and slender, that they easily might be mistaken for most elegant and delicate plants. Ladies collect them on the beach, and, having placed them in their albums, some are pleased to call them "sea-weed." Beautiful, certainly, are sea-weeds of this kind when so collected and even when so placed; but, if a sea-weed such as this,

Fig. 26.

instead of being dried as in the herbarium of a botanist, had been examined living, whilst immersed in the salt water where it grew, the spectacle had then, indeed, been worth contemplating. The

least branch, the smallest twig, or most minute filament of one of these delicate structures—of the zoophyte, for example, of which a figure is here given (fig. 26)—presents a scene of wonder whilst it is alive and in its native element. One side (or oftener both) of every slender branch is fringed with little horny cups, arranged in different modes, in various forms of *Sertularidæ;* and in each one of all the thousand cups

Fig. 27.

observed upon a coralline like this is placed an active, hungry polyp; thousands of mouths feeding one common body, which is placed *within* the horny branches of the skeleton.

The stem, and every part derived therefrom — each thread, for such the branches sometimes seem viewed by the naked eye, is found, examined closely, to be tubular, and filled from end to end with a soft substance, in the same manner as the elder tree has every bough filled up with pith. The semi-fluid pith that thus passes through every portion of a *sertularia*, is, in fact, the living animal to which the active polyps, fishing from the external cups, minister food that afterwards becomes diffused, from stem to stem, to the remotest parts.

The cups seen upon the skeleton of a *sertularia*, wherein the eating polyps reside, must, however, be distinguished from other receptacles (fig. 27. *b*, *c*) which are deciduous. These make their appearance only at stated seasons of the year, sprouting forth from what the botanist would call the "axillæ" of the branches. In these deciduous cups the germs of a new race are formed and perfected, until permitted to escape, and then become diffused extensively throughout the sea.

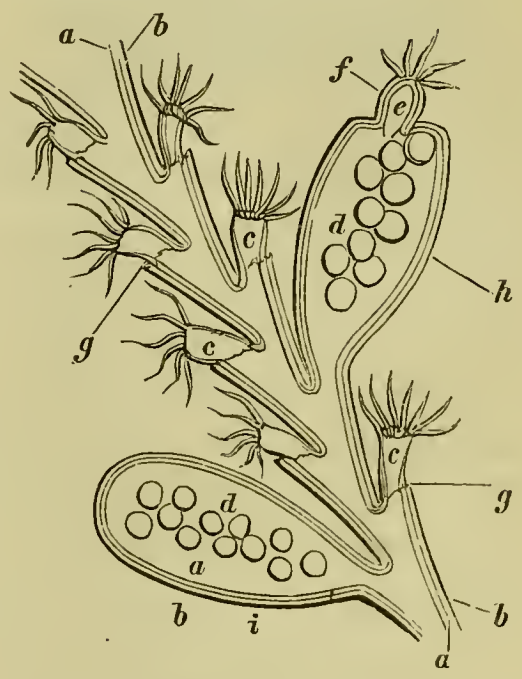
The nature of these germs, their mode of growth and manner of birth, have been detailed by several writers; but, as it would seem, without sufficient strictness of research to warrant the conclusions they have drawn. One of our best examiners* of native zoophytes asserts, that, at the proper season of the year, he saw a polyp like a *hydra* grow in each of the deciduous cups, and that such polyps falling to the ground were germs that soon assumed the form and aspect of the original from whence they

* Ellis.

sprang. A far more recent writer, Professor Grant, on the other hand, assures us that, instead of any polyp being formed, the re-productive germs are gemmules, covered with moving cilia, like to those upon the gemmules of a sponge, and that these ciliated globules, as soon as the enclosing capsules permit them to escape, swim about for a time exactly as the young of sponges do, till they attach themselves to some foreign substance and begin to assume the arborescent structure of their parent. When two authorities, such as those alluded to, clash diametrically, it becomes a subject of importance to decide the truth and settle where the difficulty exists.

In the case before us, it appears, from subsequent researches,* that the observers quoted were both right up to a certain point; but neither of them fully ascertained the whole of the phenomena exhibited; the different steps of the process are represented in the accompanying diagram (fig. 28).

Fig. 28.



The ramose body of the *sertularia*, like that of the *tubipora* above described, consists of two layers, a tegumentary layer (*b*) that expands into the branched

* Lister, Phil. Transactions.

skeleton and hardens into horn as it acquires the necessary proportions; and a nutritive layer (*a*), lining the tubes within, which is subservient to nutrition.

At proper times, when re-productive vesicles are to be formed, the outer layer expands to form the cups (*h*) wherein the germs are nurtured, and from the inner layer sprout forth the germs (*d*) to fill the horny capsule; these enlarge; the most mature approach the opening of the cup and there protrude (*e*), but as they still advance the outer layer extended over them assumes a polyp-like appearance (*f*) that includes the ciliated gemmules, this falls off, and then the germs escape and swim about in search of fit localities where they may fix and grow.

The *Sertularidæ,* as must be obvious from what has been already stated, form an interesting and peculiar group of zoophytes; one which it would be difficult to confound with any other tribes that we have contemplated. But there are other animals in outward form and general aspect closely resembling *Sertularidæ,* whose inward structure is exceedingly remote from what is found in the more simple polyps we are now considering. The young zoologist will find, however, little difficulty in distinguishing them, if examined in a living state. The *Sertularidæ have simple arms or unciliated tentacles. The higher polyps* (Bryozoa), hereafter to be noticed, *have their arms covered with moving cilia,* and this distinction will be found to involve important consequences.

Actiniadæ. Between the plant-like beings that have hitherto occupied our attention, and higher creatures that await us further on, must be placed

the *Actiniæ*, or *animal flowers*, so abundantly met with on every coast. These extraordinary productions of nature, called, fancifully, by the frequenters of the beach, "Sea-Marygolds" and "Sea-Anemonies," are found, sometimes in great variety, upon our shores; and almost every shallow pool, or rocky basin, left by the retreating tide, contains specimens, such as that of which we give a drawing (fig. 29), fixed to the rocks by a broad fleshy base, and spreading out tentacula in numerous rows, waiting the approach of prey, or else, if danger threaten, closing up and shrinking into rounded lumps scarcely distinguishable from the surface upon which they are attached.

Fig. 29.

These polyps differ widely from all those we have yet noticed, in many points of their economy. Their fleshy substance, no longer soft and jelly-like, assumes a fibrous texture and exhibits strength unparalleled in other zoophytes. We are not, then, surprised to hear it stated that they can detach themselves at pleasure from the rock, and creep about in search of situations fit to yield them food. They have no eyes, yet so susceptible are they of light, that not a cloud can pass before the sun but they will show by shrinking that they feel the change. Should an unlucky crab, though stronger far, apparently, and much more

active than the zoophyte, touch the expanded arms activity and strength avail it little; with slow, but pertinacious and unflinching grasp, the actinia seizes hold of it and, soon involving all its limbs with the tentacula around its mouth, the victim gradually is dragged into the polyp's stomach there to perish; all its softer parts—all that can be nutritious is digested and dissolved, until, at length, the actinia being satisfied with its abundant meal, opens again its mouth, and thus regurgitates the shell and what is indigestible. Nor does a little food suffice to satisfy its appetite; the actinia is voracious, harmless and flower-like though it seems; sometimes, for instance, it will swallow whole three or four mussels for a breakfast, and dissolve them all except the shells before the latter are cast out as being unfit for aliment.

Being thus endowed with such surprising attributes we naturally enquire what is the structure of so strange a creature? how can it perform actions that seem so unaccountable without some special mechanism to which its powers may be attributed? All that anatomy reveals in answer to these queries may be seen in the appended figure (fig. 30), which we will, therefore, now proceed concisely to explain. The figure represents an actinia cut in two, divided through the middle, and displays the relative position of the parts within. The mouth, which occupies the centre of the circles of tentacular rays, communicates with a capacious bag placed in the interior of the body (*c*): this is the stomach, and its ample folds proclaim its great capacity. Between the stomach (*c*) and

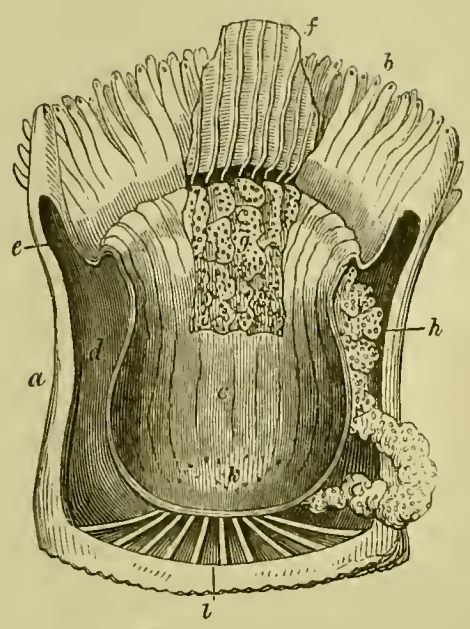
the fleshy skin (*a*), here widely separated, are spacious cavities divided by compartments from each other but communicating freely. These chambers during life are filled with water which can be propelled into the hollow arms around the mouth (*b*, *e*). Would we, therefore, understand the means whereby the actinia protrudes its tentacles and opens like a flower, or draws them back again and shrinks into a shapeless mass, whenever it thinks proper; we at once perceive the simple mechanism employed. Seeing that every one of the tubular tentacula communicates with the general cavity situated between the stomach and the skin, or fleshy tegument, precisely in the same manner as the fingers of a glove communicate with the part that receives the hand, the actinia wishing to spread out its arms expels the water from its body and thus fills the arms, which, being distended tensely, stand erect and radiate like the petals of a flower. Or, should it wish again to shrink from observation, it contracts in turn the tentacles themselves, and forces the water they contained back into the cavity of its body, or squirts it in jets through holes pierced at the end of each tentacle. The tentacles collapse, the body closes, and states as opposite as those delineated in the last figure (fig. 29) are the results of this antagonism, the beautiful form is entirely lost, the rays disappear, and the actinia becomes converted into such a shapeless mass as not to be recognisable upon the naked rock.

There is this important difference between the ocean and the earth. The land only nourishes living

beings on its surface. Some creatures, indeed, may burrow to the depth of a few feet beneath the soil, and some may rise a little distance into the air, but that militates not against the grand fact, that the earth is only populated upon its surface, and the vegetable banquet there spread, is abundantly sufficient to afford sustenance to all terrestrial animals. Far different is it, however, in the sea; the ocean is peopled at every assignable depth, from its profoundest recesses to the crest of its highest wave, and where, by possibility, could vegetable materials be found to feed a progeny so countless? The bottom of the deep, or the surfaces of submarine rocks, let them be ever so thickly clad with appropriate vegetation, would afford but a scanty supply, compared with the demand for nutriment; if food must be provided here, that food must be of a living kind, and animal diet must be furnished, in adequate abundance, to maintain myriads of hungry mouths beyond all human estimate.

Philosophically considered, therefore, and taking a comprehensive view of nature, it is not difficult to perceive the uses of these humble zoophytes. They are themselves to be devoured at last; but whilst they live they are to furnish other food and pour forth offspring with a prodigality that might overwhelm the ocean, were there not destroyers there as multitudinous as the supply is vast. The fecundity of these plant-like animals must, therefore, be excessive; and, indeed, it is difficult to find language sufficiently strong to give an idea of their fertility. Taking the actinia as an

Fig. 30.



example, we shall find, on dividing the body of one of these creatures so as to expose its interior, that every one of the compartments situated between the stomach and the skin contains a delicate but most extensive membrane or thin film wrapped up in complicated folds: (fig. 30, *h*) from this membrane are seen to sprout forth millions of little eggs, or germs of future animals destined in time to be expelled into the sea, and these, although ordained to be destroyed almost as soon as formed, act no unimportant part in the economy of Nature; for they become the food of multitudes of more exalted beings which without such sustenance could not exist at all.

But how do the eggs escape out of the interior of the zoophyte? This is a question not yet positively settled. There are, however, situated at the bottom of the stomach of the actinia, several minute apertures (*k*) apparently communicating with the egg producing membranes; and most probably the little germs issue through these orifices into the stomach of the parent creature, whence they are expelled through the mouth of the actinia to be devoured by other inhabitants of the deep, hungrily awaiting the supply.

CHAPTER VI.

INFUSORIAL ANIMALCULES. POLYGASTRICA. (Ehrenberg.)

> "Full nature swarms with life; one wondrous mass
> Of Animals or atoms organized."

THESE are the words of a poet familiar to us all; but, perhaps, when their author penned the lines he little thought how strictly and philosophically correct was the daring assertion contained in them.

Take any drop of water from the stagnant pools around us, from our rivers, from our lakes, or from the vast ocean itself, and place it under your microscope; you will find therein countless living beings, moving in all directions with considerable swiftness, apparently gifted with sagacity, for they readily elude each other in the active dance they keep up. And since they never come into rude contact, obviously exercise volition and sensation in guiding their movements.

Increase the power of your glasses and you will soon perceive, inhabiting the same drop, other animals, compared to which the former were elephantine in their dimensions, equally vivacious and equally gifted. Exhaust the art of the optician, strain your eye to the utmost, until the aching sense refuses to

perceive the little quivering movement that indicates the presence of life, and you will find that you have not exhausted Nature in the descending scale. Perfect as our optical instruments now are, we need not be long in convincing ourselves that there are animals around us so small that, in all probability, human perseverance will fail in enabling us accurately to detect their forms, much less fully to understand their organization!

Vain, indeed, would it be to attempt by words to give anything like a definite notion of the minuteness of some of these multitudinous races. Let me ask the reader to divide an inch into 22,000 parts, and appreciate mentally the value of each division: having done so, and not till then, shall we have a standard sufficiently minute to enable us to measure the microscopic beings, upon the consideration of which we are now entering.

Neither is it easy to give the student of nature, who has not accurately investigated the subject for himself, adequate conceptions relative to the numbers in which the Infusoria sometimes crowd the waters they frequent; but let him take his microscope, and the means of making a rough estimate, at least, are easily at his disposal. He will soon perceive that the animalcule-inhabitants of a drop of putrid water, possessing, as many of them do, dimensions not larger than the 1·2000th part of a line, swim so close together that the intervals separating them are not greater than their own bodies. The matter, therefore, becomes a question for arithmetic to solve, and we will pause to make the calculation.

The *Monas termo*, for example,—a creature that might be pardonably regarded as an embodiment of the mathematical point, almost literally without either length or breadth or thickness — has been calculated to measure about the 22,000th part of an inch in its transverse diameter; and in water taken from the surface of many putrid infusions, they are crowded as closely as we have stated above. We may, therefore, safely say, that, swimming at ordinary distances apart, 10,000 of them would be contained in a linear space, one inch in length, and consequently a cubic inch of such water will thus contain more living and active organized beings than there are human inhabitants upon the whole surface of this globe! However astounding such a fact may seem when first enunciated, none is more easily demonstrated with the assistance of a good microscope.*

Our next inquiry must be concerning the forms

* In an address lately delivered before the Microscopical Society of London, Professor Owen, the president, in allusion to researches such as these, observed that, in Creation "everything is great or small only by comparison. The telescope teaches us that our world is but an atom, and none know better than microscopical observers that every atom is a world. If the astronomer be led from the contemplation of the countless orbs that traverse boundless space, to the adoration of the Creator in His almightiness; so the observation of the perfections of His minutest works, which, though invisible to ordinary ken, unfold new perfections with every increased power of observing them, ought to impress us with a lively sense of that all-caring-for and all-seeing Providence without whom not a sparrow falls to the ground and by whom every hair of the head is numbered."

and general structure of these *animalcules*, as they are most correctly called, and if our investigations in connection with this subject promise to afford us considerable interest, we shall hardly be surprised if they involve some little disputation seeing the extreme minuteness of the objects of our study.

We have already seen that there is no possibility, by any definition as yet laid down, of precisely pointing out the line of demarcation which separates the animal from the vegetable creation. In the sponges and polyps we found animals rooted and fixed like vegetables; and we apprehend it is not less a fact that, among the animalcules, on the history of which we are about to enter, there are vegetables endowed with locomotion, and trenching, as it were, upon the limits of the animal domain; yet stealing into it so gradually that the zoologist and the botanist are equally at fault to decide where the boundary has been crossed.

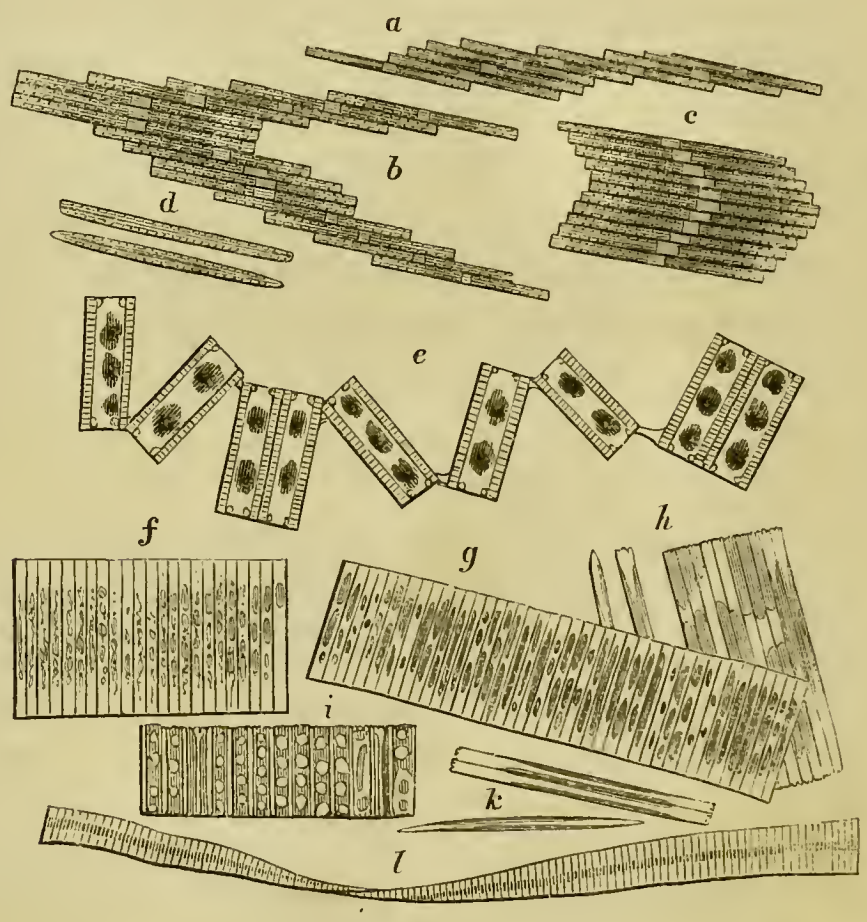
The professor of botany would undoubtedly lay claim to the *Confervæ* as belonging to the vegetable division, and doubtless some species do; but there are confervæ most distinctly endowed with life, capable of feeling, and able to move about from place to place.

Various are the forms of these confervoid animalcules, many of which are delineated in the next and succeeding figures. They are frequently met with abundantly in ditches, and other stagnant waters; and not a few of them exhibit compound structures of extreme beauty and interest. Generally they consist of exceedingly minute silicious trans-

parent tubes ranged side by side in definite and precise directions.

In different forms of *Bacillaria* (fig. 31 *a*, *b*, *c*), for example, these tubes are variously disposed, the ends of the succeeding ones projecting beyond the last; in other cases, as in the *Fragillariæ* (*f*, *g*, *h*, *i*, *k*, *l*), they are very regularly placed, side by side, forming

Fig. 31.

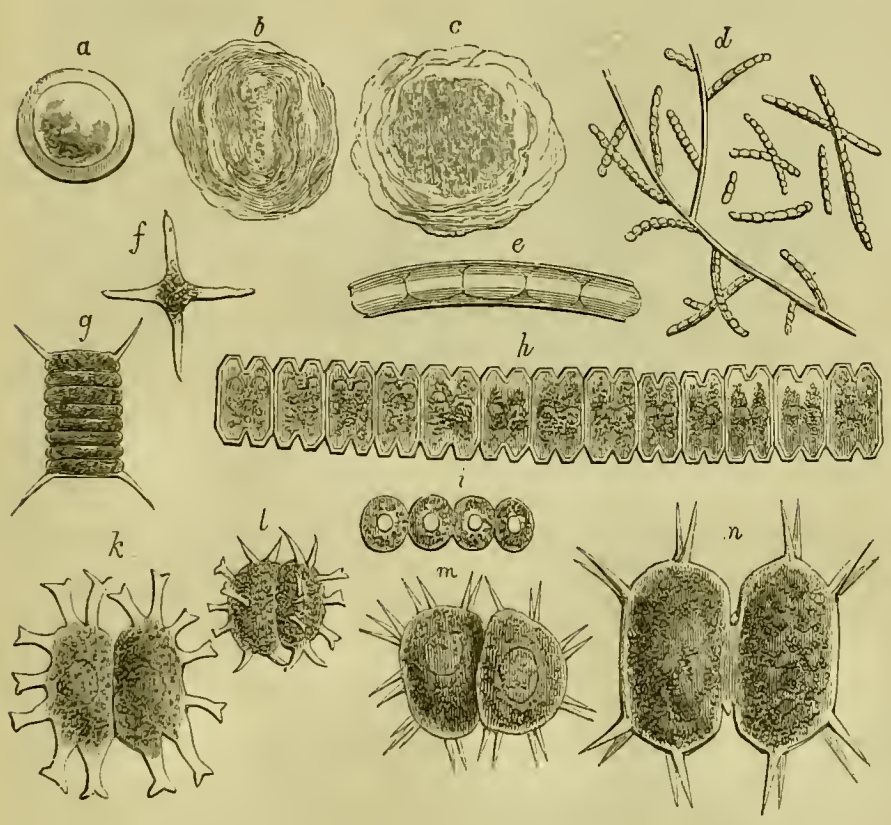


long flat ribands made up of numerous conjoined cylinders laid parallel to each other. Every tube is more or less completely filled with a granular, soft substance, of different colour in different species, but

without any appearance of a stomach or other internal apparatus; nevertheless, these creatures are able to move on their own axes, and to progress in a manner we are not able to understand, because we cannot see the organs producing this motion. Frequently, these tubes appear to march in microscopic regiments, keeping the same form, and never varying from the order of procedure in which they first set out.

The *Pixidicula* (fig. 32, *a*) is a transparent globular

Fig. 32.

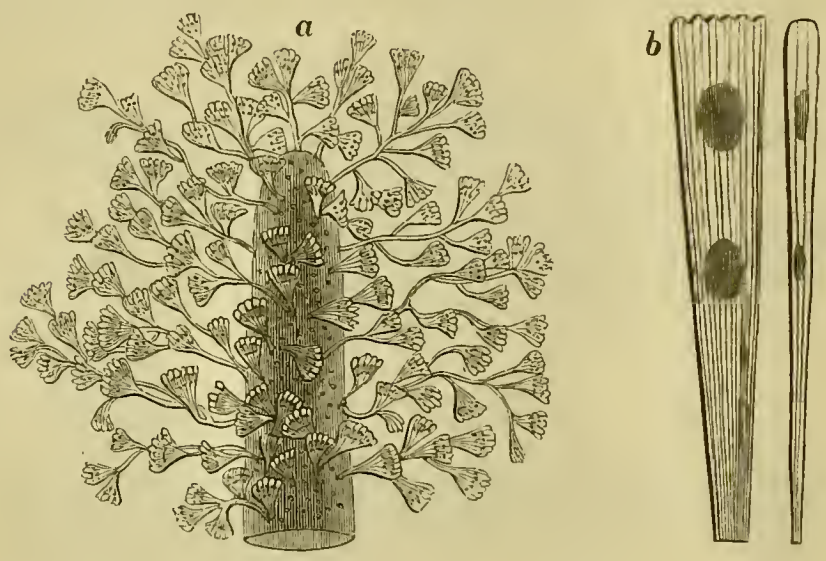


shell, enclosing a small portion of living matter. The *Gaillonella* (*d*), of which a magnified portion is represented at *e*; the *Staurastrum* (*f*), the *Arthrodesmus* (*g*), the *Desmidium* (*h*), and the various species of *Xanthidia* (*i*, *k*, *l*, *m*, *n*), are all of similar organ-

ization and will serve, at least, to give the reader an idea of the outward forms and general appearance of these dubious members of creation.

In *Echinella* (fig. 33, *a*) we have a still more exquisitely-constructed specimen of a confervoid animalcule, made up of groups of microscopic fans; every ray of which, when magnified as in the figure (*b*),

Fig. 33.

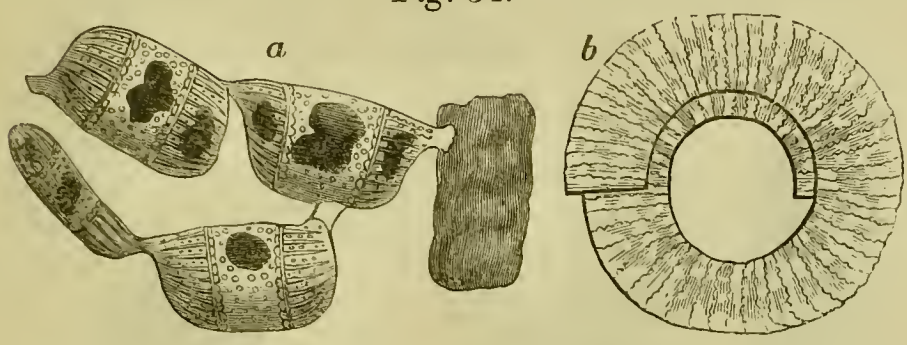


presents a perfect shell filled up with living substance. These are found in multitudes upon the surface of aquatic plants, to which they are attached by little stems, and, if their size were not so small as to render them almost imperceptible to an ordinary observer, few more agreeable spectacles could be pointed out than that which they exhibit.

The *Meridion* (fig. 34, *b*) and the *Isthmia* (*a*) are not less curious examples; for they show how elegant in sculpture and how delicate the shells may sometimes be in creatures else so inconspicuous. And in *Synedra* (fig. 35), as though to crown these wonders,

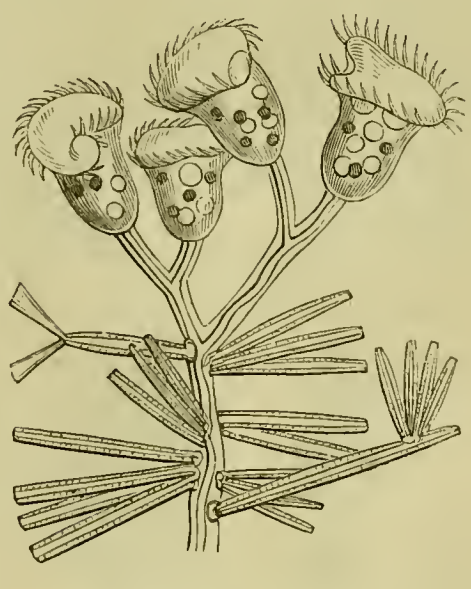
we perceive that even animalcules may have parasites attached to them. In the figure alluded to, the reader will at once perceive that the stem of a

Fig. 34.



Vorticella, an infusorium, the economy of which we shall describe hereafter, may be made the resting-place of more humble creatures, lower still in powers and organization; but what are we to say, when we find our fountains and our streams decorated not inappropriately with living insignia of the order of the Bath?—compound beings of a similar character to those last described; but in which the newly-formed animals are regularly disposed around the originals from whence they sprouted, until they resemble the decorations and the stars that adorn the noble and the illustrious of our own race; such, for instance, as the *Micrasterias,* of which various representations are given in fig. 36, (*a,*

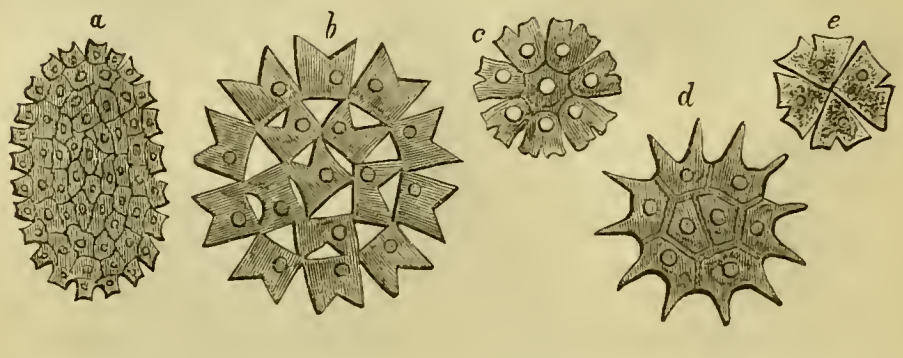
Fig. 35.



b, c, d, e,) all of which, in everything but outward form, are most nearly allied to those we have already noticed.

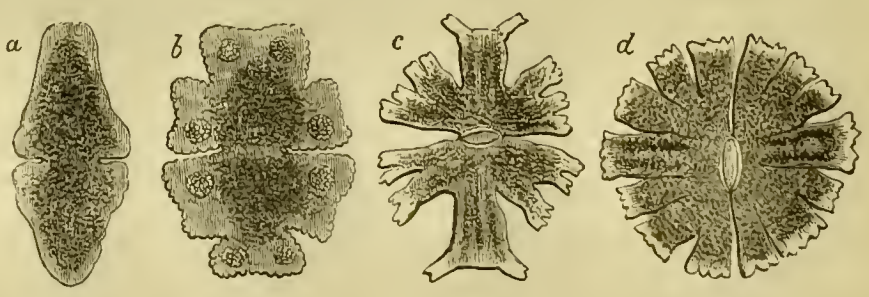
Other species (*Euastrum*), intimately related to the

Fig. 36.



same family, seem even more decidedly plant-like; the delicate and almost invisible shell, which forms the external investment of their bodies, presents considerable symmetry of shape, and is found to be deeply fissured in different directions. Internally it is filled up with a greenish granular substance, that is easily squeezed out by violent pressure, or escapes

Fig. 37.



when the shell is fractured; nay, even when the shell is unbroken, it by no means entirely fills it (fig. 37, *a, b,*

c, *d*). In its appearance, indeed, and in every particular, the contained material seems still of vegetable character, notwithstanding the affinities that may be pointed out between these beautiful structures and the Infusoria.

Gradually we now rise to the consideration of more perfectly-developed beings, more active forms of Infusoria. The *Monads* (already alluded to as being amongst the smallest creatures cognizable to the human senses, even when aided by the most powerful microscopes, and then appearing as mere moving points) (fig. 38, *a*) are sometimes met with of sufficient size to allow the microscopical observer to obtain, at least, a glimpse of the details of their economy. The *Monas Termo*, for example (fig. 38, *b*), has an appendage resembling a tail, giving to each the semblance of a microscopic Tadpole. But, as we are told, the organ that, in appearance, emulates the tail of the Tadpole, is not a tail, but a mouth or proboscis, by the aid of which the little creature can either swim or obtain food at pleasure. And yet, when we reflect that these animalcules are themselves so small as almost to elude observation, we must leave the reader to

Fig. 38.

appreciate for himself the dimensions of this proboscis or tail, to which we are now alluding.

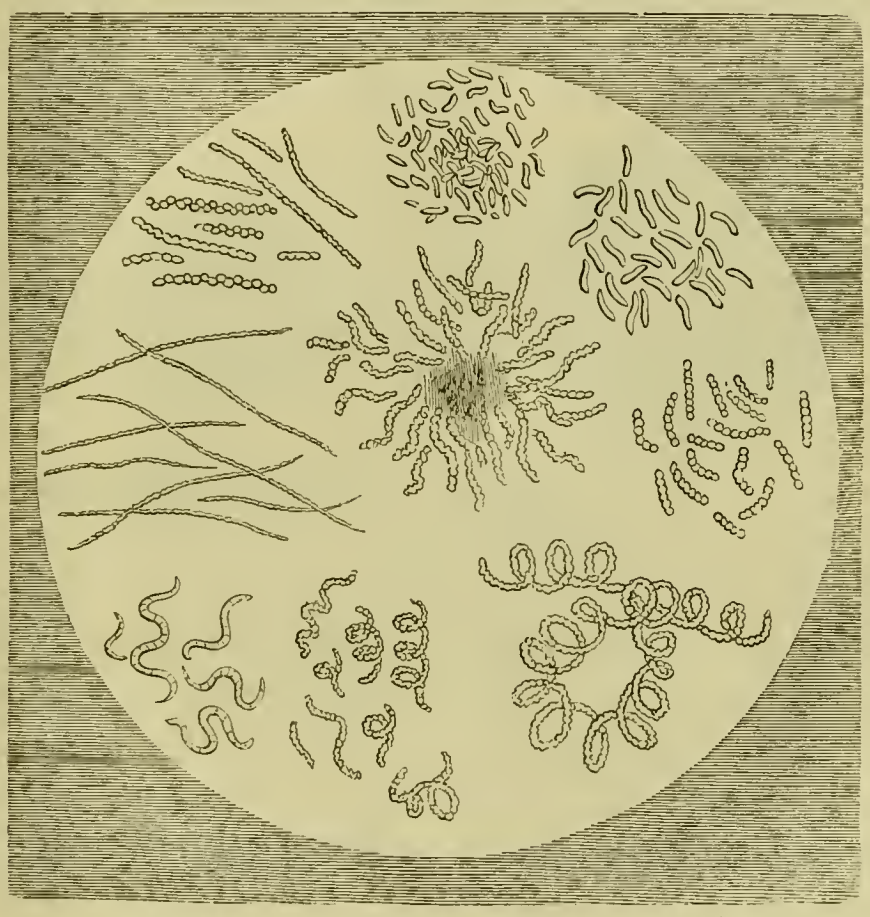
More than this: we are informed that these nearly invisible monads have stomachs in their interior; and most decidedly, if you keep them in water wherein certain vegetable colouring substances have been infused, for instance, very finely-levigated carmine or indigo, three or four coloured spots, represented in the figure, will soon become apparent in each animalcule, obviously produced by the introduction of the vegetable matter employed. Whether the cavities containing the coloured particles are *stomachs* or not is a question to be discussed hereafter; it is sufficient for us to perceive, just now, that even these monads, so indescribably minute as they are, present a distinct organization and some complexity of structure, that they are capable of locomotion, as well as of seizing food; and have, moreover, senses sufficient for their guidance.

The *Uvella* (fig. 38, *c*, *d*, *e*), the *Polytoma* (*f*. *g*), and the *Microglena* (*h*, *i*), are other species almost equally microscopic, and their attributes as remarkable.

But various are the forms presented by different genera of these beings, and some of them not a little strange. In water where meat has been allowed to putrefy, millions of millions of spiral or wavy filaments are seen in rapid motion, screwing themselves along, like tiny cork-screws, through the drop that they inhabit, and presenting sundry different shapes delineated in fig. 39. The length of

these *Spirilla*, as they have been named, varies, perhaps, from 1·1000 to 1·3000 of an inch, and the tenuity of their filamentary bodies is, of course, extreme; yet they are obviously alive, and sport about with every appearance of enjoyment.

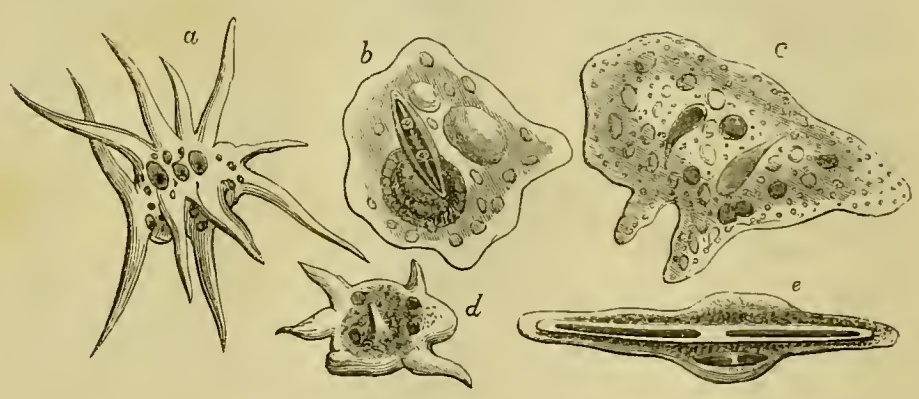
Fig. 39.



The *Proteus* (*Amoeba Diffluens*) is an animalcule of a totally different shape, if indeed shape that can be called that shape has none. This animalcule is not unfrequently met with in some vegetable infusions; and, under the microscope, appears to consist of a mass of grey-looking jelly, a film that

can change its form at will, and assume every diversity of outline. Sometimes, you will find it shrunk up into a gelatinous ball, then shooting out rays in all directions, which appear like limbs, or moulding itself into any form adapted to the shape of animalcules it may choose to swallow for its food; for, even here we find carnivorous destroyers. The figure given below (fig. 40) will serve to show a

Fig. 40.

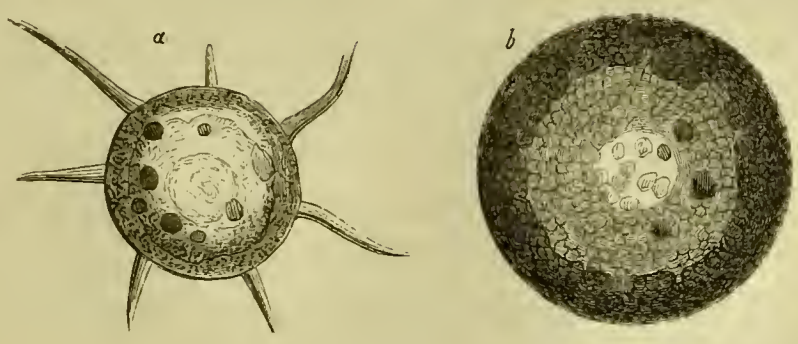


few of the vagaries of this hungry mass, and at *b*, *c*, and *e*, the swallowed animalcules of different species seen within the *Amœba*, testify to its voracious disposition.

Some Infusoria nearly allied to the *Proteus*, and furnished with bodies equally contractile, are able, notwithstanding the mutability of their shape, to construct for themselves shelly defences beneath which they can retire for shelter or protection. In the *Arcella*, for example, (fig. 41. *a*, *b*,) you find an *Amœba*, for such it is essentially, covered over with a shell, resembling that of a limpet; and truly there are some physiologists fanciful enough to

imagine that we have here, in rudiment, the sketching out of what in higher animals will show itself under more perfect forms; so that the shell-fish and the tortoise are here typified amongst these humblest animals. How that may be, we will not pause to ask; it is sufficient for our present purpose to learn, that, minute as these Infusoria are, they are, many of them, able to construct for themselves shells

Fig. 41.



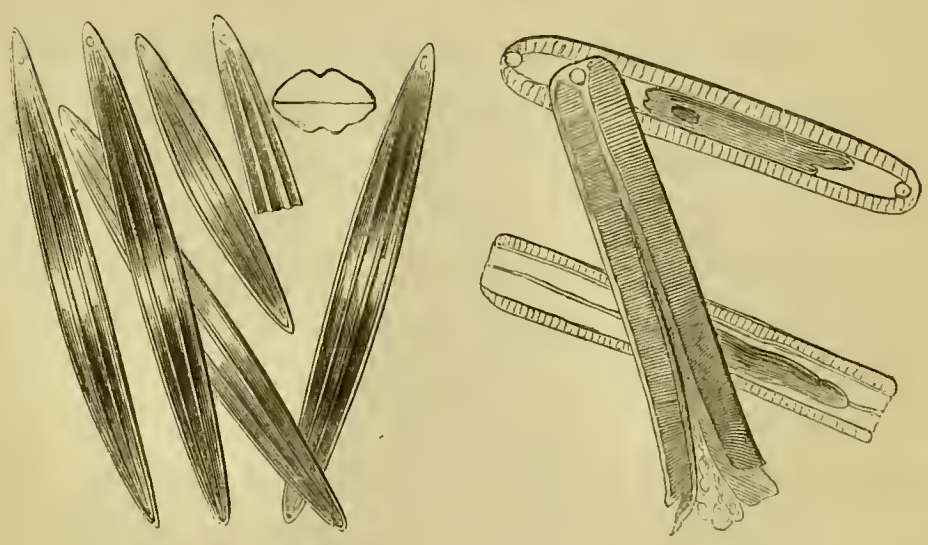
of extreme beauty and elaborate workmanship, which, under a good microscope, will bear comparison with the most exquisitely sculptured that are to be found in the cabinets of the conchologist.

It is not, however, from their minuteness or their beautiful sculpture that these microscopic shells principally merit our notice: small and invisible as they are individually, it is perfectly possible that, in the lapse of ages, even these exuviæ of animals, of whose very existence man would for ever have remained ignorant but for his glasses, may, by their accumulation, absolutely change the geological features of whole regions of this world, and give rise to the existence of strata of soil, of no trivial interest or importance. We have before us a quantity of earth,

brought from the shores of Lake Lettnaggsjon, near Urnea, in Sweden; an earth which the inhabitants of that country have, from time immemorial, regarded as being nutritious, and from this circumstance, as well as from its whiteness and excessive fineness, it has received from them the name of *Bergmehl*, or mountain meal. Mixed up with flour this substance is even used for bread; and was formerly thought to be an exception to one of the most incontrovertible facts with which we are acquainted, namely, that the mineral kingdom does not furnish food for the support of animals.

Ehrenberg, the illustrious investigator of the creatures we are now considering, struck with the singularity of this mountain-meal being nutritive, examined it microscopically, and his well-practised eye

Fig. 42.



at once detected that it was entirely composed of the shells of animalcules. These (fig. 42), the pro-

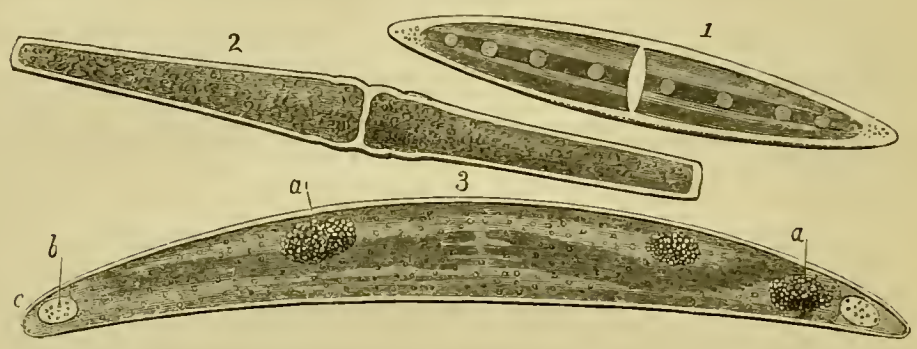
ducers of the shells in question, had for ages occupied the waters of the districts where the nutritious soil is found, and generations after generations having perished in countless thousands, their exuviæ continually subsiding to the bottom, have slowly formed a stratum of earth of such thickness as really to be an important article of diet to the inhabitants of the country, in consequence of the quantity of animal matter entering into the composition of the shells.

The discovery of the real nature of the *Bergmehl* was, however, but the first step in a field of investigation that now promises to be of boundless extent, and fossil infusoria have since been everywhere met with in startling abundance. The polishing slate of Bohemia *(Polischiefer)*, so extensively used on account of its adaptation to polish very fine surfaces, is entirely made up of such remains, which, from the angularity of their shape, their extreme minuteness and silicious hardness, are well fitted to the use for which they are employed by the artificer. We also possess numerous other examples, from different parts of the world; but, what an overwhelming subject of contemplation to the reflecting mind! to think that every grain of dust whereon he treads may have been a living creature; and what ideas concerning the immensity of the animal creation does not the thought suggest!

The *Naviculæ* (fig. 43, 1, 2, 3,) are examples of recent animalcules nearly allied to those entering into the composition of the *Bergmehl* described above.

Possibly we have most of us heard, in our younger days, vague rumours concerning a machine for grinding old people young again; although it is to be apprehended that, in the wildest flights of childish fancy,

Fig. 43.



we never believed it possible that such a renovation was by no means out of the ordinary course of Nature; nay, that it was, as we shall really find it to be, the most ordinary mode of re-production among animals such as we are now discussing. The Infusoria before us are acrite beings, possessed of no nerves, and still very closely allied to the members of the vegetable kingdom. Every part of their body consequently has powers of life inherent in itself, enabling each portion to exist independently of the rest; and, seeing this to be the case, we are not surprised to find that they can multiply themselves by fissure: that is to say, every individual can separate spontaneously into two or more portions, each portion becoming a distinct and perfect animal. Take, for example, a specimen of any common form, as *trichoda charon* (fig. 48, *d*), and if the little creature be well supplied with food, the whole

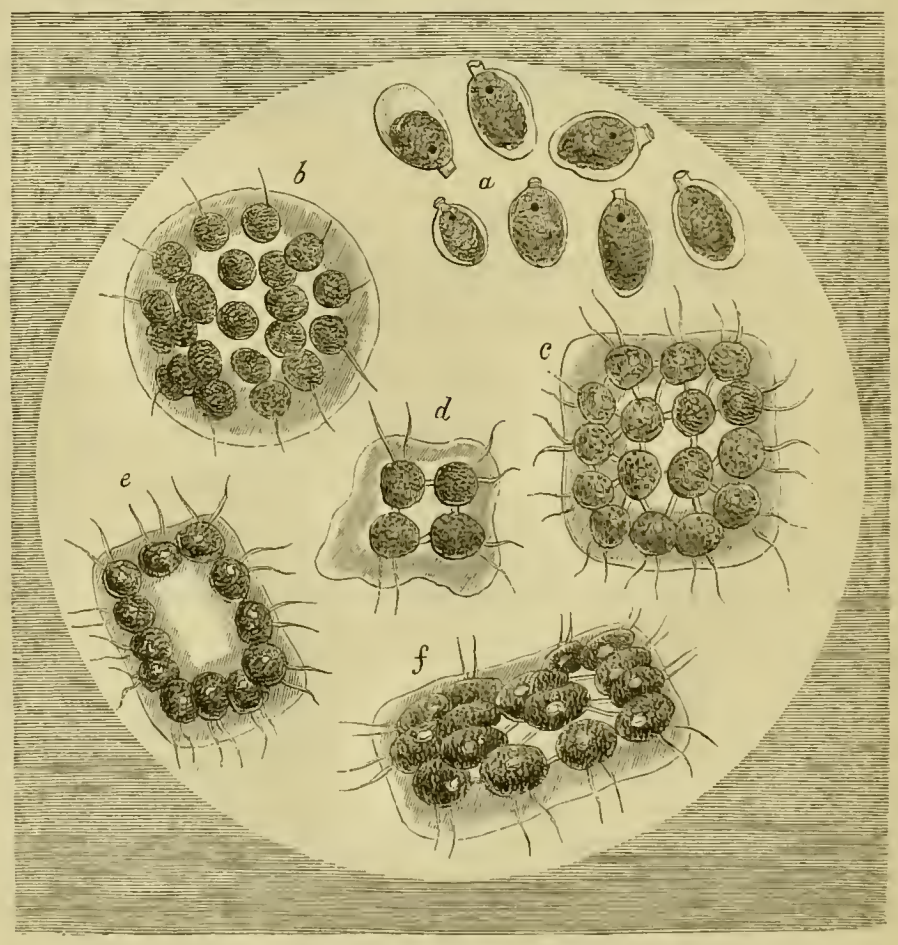
process may easily be witnessed. In the course of a few hours a transparent line is seen to make its appearance, passing across the body, either transversely as at *a*, or longitudinally, *b*, or sometimes obliquely. An indentation soon appears at each extremity of the transparent line, and this indentation becoming gradually deeper and deeper, the body of the old animalcule becomes slowly divided into two halves, only connected by a narrow isthmus or pedicle. The pedicle at length is removed, and, the two divisions parting company with each other, the original being is literally changed into two young ones.

This mode of increase is extremely rapid seeing that each division, or new creature, if well fed, will, in the course of a few hours, again repeat the process; but, supposing such spontaneous fissure only to occur once in twenty-four hours, at the end of twenty-six days the progeny derived from a single animalcule would amount to 23,554,432, and a summer-month of thirty-one days would witness the production of upwards of seven hundred and fifty three millions of such infusoria derived from a single individual! Well, therefore, may the very drops of water swarm with creatures possessed of such extraordinary powers of increase, and the bottoms of the ponds or lakes where they abound be thickly covered with their indestructible remains!

Prodigious as are the powers of re-production, in the ordinary animalcules just referred to, there are certain races that are still more prolific inasmuch as they divide spontaneously into more numerous parts.

The *Gonium pectorale*, for example (fig. 44, *c*),—a creature so called, because its compound body resembles the breast-plate worn by the Jewish High Priest,—will divide, by transparent lines that cross each other at right angles, into sixteen distinct animals, and each of these again, having attained to its full growth, is ready to separate into sixteen more.

Fig. 44.



There are various species of these *Gonia*, some of which are represented in the above figure (fig. 44, *b*, *c*, *d*, *e*, *f*). If examined accurately under a good glass they all appear to consist of agglome-

rations of *Monads;* that is to say, of creatures furnished with a proboscis like that of the simple monad previously described, joined into one group and encased in a transparent shell that unites them into one common body. A single or double proboscis, derived from each enclosed monad, pierces the translucent envelope, and these organs seem to be the agents employed in obtaining nutriment and likewise the instruments of locomotion. Such, at least, is the account that Ehrenberg gives of the structure of these remarkable beings; and there appears to be little doubt of its accuracy.

The *Enchelis*, or *Flask Animalcule*, is another form very commonly met with, and extremely beautiful. It resembles, most accurately, a Florence-flask of such minute dimensions as to be barely visible to the naked eye. Examined under the microscope the mouth of this tiny flask is seen to be surrounded with a circlet of animated cilia capable of moving themselves by some innate power hereafter to be considered; and producing, by their action, rapid currents in the drop of water wherein the creature swims. The cilia thus supply both the apparatus employed for locomotion, and also the means of procuring food, for the vortex caused by their vibration hurries into the mouth of the little *Enchelis* whatever animalcules, or organized particles, may come into its vicinity; and thus the creature is fed, with little effort on its own part, the side currents upon the margin of this miniature whirlpool, carrying off to a distance whatever may be rejected as improper for nutriment.

We have, hitherto, only dwelt upon the external configuration and general appearances presented by these smallest of animal existences. It now behoves us to examine, a little more minutely than we have as yet had occasion to do, what are the opinions prevalent among physiologists concerning their internal structure.

The lowest forms, as has been observed in a preceding page, are evidently nearly related to the vegetable world; and, perhaps, more decidedly belong to the vegetable division of organized bodies than to that properly called animal. They consist internally of what would seem to be vegetable tissue, and this is enclosed in a thin shell, microscopic in size and most delicate in texture. When the shell is broken, the matter contained within escapes through the orifice caused by the fracture; and thus you may obtain the shell emptied of its living part. The formation of a shell or silicious crust, is by no means a prerogative granted exclusively to animals; but, on the contrary, is frequently observed in the vegetable kingdom; as, for example, in the stems of reeds and grasses, not to mention the confervæ, where the shelly crust is evidently of vegetable origin.

The manner in which these confervoid animalcules are re-produced is, moreover, obviously allied to the mode of growth in vegetables. New animals, if you choose so to call them, or new vegetable sprouts from these living plants, are seen to be developed again and again from those last produced; and these, as they become perfected, assume definite arrange-

ments characteristic of the species to which they belong, but numerous examples have already been given (*vide p.* 102).

These bodies differ, however, from the generality of vegetables, inasmuch as they are endowed with a power of voluntary motion. No sooner has a new being been developed, like a bud from its parent, than it is able to separate itself, to a certain extent, from the stock whence it was derived; and whole chains of them, thus situated, are frequently met with, presenting, under the microscope, the appearances delineated in preceding figures.

As we advance from these vegetable forms of Infusoria to the more highly-organized tribes where greater activity is conferred, and organs become multiplied, the discussions concerning the internal economy of the Infusoria assume additional importance.

Even in the most minute *Monads* that can be investigated, it is easy to perceive, when they are examined with a very perfect glass, that the body of the little being contains granular specks; and if colouring matter be placed in the water where the monad resides, these specks will assume the tint of that colouring substance. The first question to be solved, therefore, is — What are the granules that are thus capable of imbibing from without coloured particles?—What name is to be given to them?

Ehrenberg, who has examined and described the Infusoria with more attention and success than any one else, has declared that the organs in question are

so many *stomachs*, and, in consequence of this assertion on the part of so eminent an authority, most zoologists are contented, at the present time, to name the whole class POLYGASTRICA; that is, animals possessed of numerous stomachs, and so sanctioned is this opinion by modern science that to deny the correctness of Ehrenberg on this point would seem to be almost heresy. Let us, however, giving the inquiry all the importance to which it is entitled, examine coolly how far we are justified in unreservedly adopting the opinion of the illustrious Professor of Berlin, as relates to this part of the economy of the Animalcules under consideration.

The granules, or globular vesicles, apparent in the interior of these little beings, and which are called by Ehrenberg *stomachs*, are described by that eminent observer as communicating immediately with the mouth of the creature, or else as being appended to the sides of a wide canal, which passes in various directions through the body; and he has even classified the so called POLYGASTRICA in accordance with the arrangement of the central canal in question. But, unfortunately, however beautifully diverse forms of digestive apparatus may be delineated in the magnificent plates which Ehrenberg has given to illustrate their arrangement, it is in vain that other observers, with the utmost patience and diligence, and aided by the best microscopes, have sought for the slightest vestige even of the central tube, much less of those minor branches which it is said to give off to the vesicles situated in the interior of the body; and sometimes, be it remembered, these vesi-

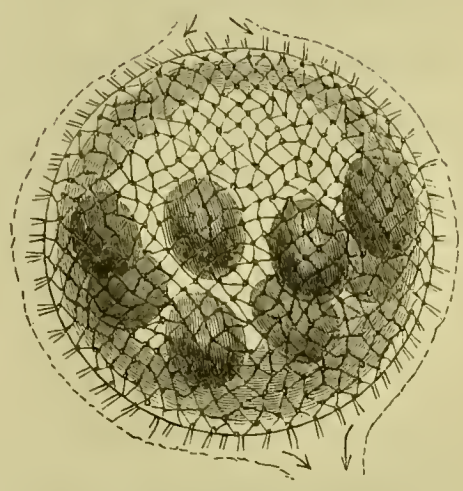
cles amount in number to upwards of two hundred. Negative evidence, however, is never of so much worth as positive evidence; and Ehrenberg would have every right to lay claim to superiority of observation, were there not other circumstances appearing to militate strongly against the accuracy of his views. In the *Paramecia,* for instance,—very common and, comparatively speaking, very large animalcules,—these vesicles are examined with great facility. In these creatures I have watched the globules again and again, and seen the individual vesicles pass round the body two or three times in succession, circulating exactly in the same way as the sap is seen to do in *Chara,* and other transparent plants, or as the fluids contained in the stems of some tubular Corallines. If, therefore, they can thus freely change their position, how is it possible that they can be pedunculated or attached to such a central canal as Ehrenberg has figured? except, indeed, the connecting tubes be of considerable length, as well as of such extreme tenuity, as to escape the observation of the most clear-sighted microscopical examiners.

But, more than this: if we test the subject, by Ehrenberg's own observations and take his own drawings, we shall find reasons wherewith to confute what I apprehend to be an erroneous doctrine. Many of these creatures that have such microscopic mouths and minute stomachs, are known to subsist upon animalcules that are nearly as large as their own bodies. Ehrenberg gets over this difficulty by saying that the central canal,—the so-called sto-

machs—as well as the canals communicating between them, are exceedingly dilatable; and surely they must be so, if every one of the two hundred *stomachs* will expand to nearly the size of the whole animal possessing them! The *Flask-animalcule* (Enchelis) is depicted as swallowing an animalcule nearly as large as itself, which is no sooner brought, by the action of the ciliary currents above alluded to, into the vicinity of the mouth, than the oral aperture opens to receive it. But, granting it to be possible that a creature of such comparatively large dimensions can enter the common central canal, how is it to pass the delicate and invisible tubes leading to the vesicles called, by Ehrenberg, stomachs?

In the *Proteus* (*Amoeba*) we have another example, equally striking. This animalcule, as we have already seen, changes its entire shape to adapt the form of its body to the dimensions of the prey that it has swallowed, as seen in fig. 40; and it is, therefore, difficult to suppose that a victim so bulky is lodged in one of the numerous microscopic sacculi within it? Obviously, then, if the sacculi, or granules, in question, are *receptacles for the products of digestion*, which, doubtless, they are; they are not themselves the digestive organs, or, in other words, they are not *stomachs*, properly so called. Most probably, as in the hydra, or fresh-water polyp, the conversion of the food into nutriment is effected in a common central cavity, and the nutritive particles are afterwards conveyed into the smaller floating granules, there to be appropriated to the use of the animalcule.

Fig. 45



But to proceed. Among the most beautiful and wonderful of the whole series of the Infusoria, are the *Volvoces*, of which the *Volvox globator* (fig. 45) is a specimen by no means difficult to procure at certain seasons of the year.

In shape it seems a microscopic globe, rotating slowly on its own axis,—a tiny world rolling majestically through the little quantity of water that forms its space, guided by some unseen and innate power. More accurately examined, we perceive the body to be formed of a transparent spherical membrane, studded with small green dots, and having all its surface covered over with vibrating hairs of infinite minuteness, which produce currents in the surrounding water, and thus cause the revolution of the globe, as well as its progression.

The cavity of this most elegant transparent sphere is filled with fluid; and within are seen young *volvoces* rolling round and round in the interior of their parent—wheels within wheels. When first perceived, these young were merely opaque, greenish spots, that sprouted forth like buds from the inner surface of the original animalcule; but, growing larger, and having attained, in miniature, the form of that from which they sprang, they soon break loose and roll about imprisoned in the cavity that gave them

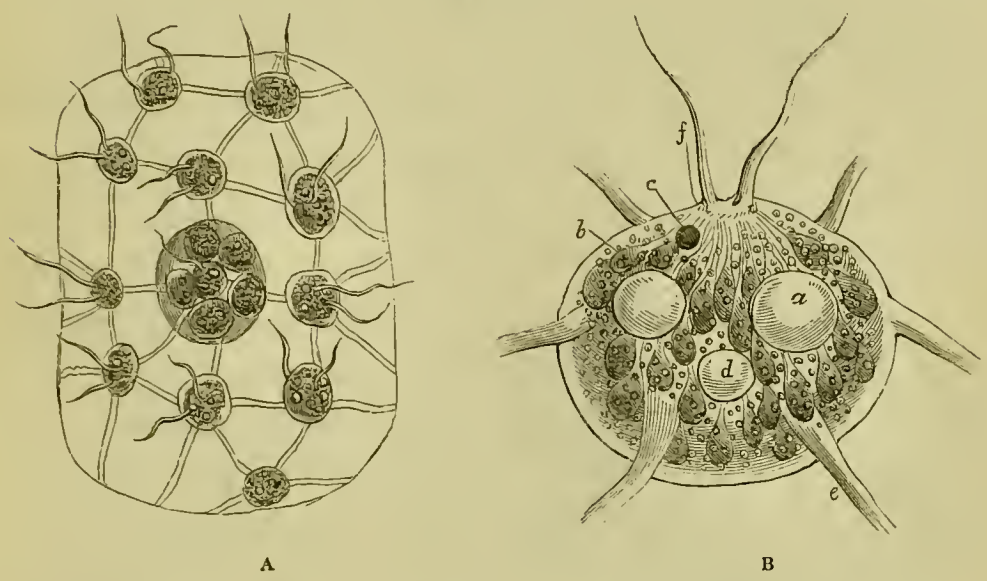
birth. At length, their growth accomplished, they escape; the parent membrane bursts, and out they swim into the surrounding water to assume an independent life. But, even before they issue forth, they bear within themselves the germs of a third race, destined, in like manner, to terminate by their liberation the existence of their parents.

But the circumstances above narrated, connected with the history of the *Volvox*, form but a small portion of the wonders revealed to us in the economy of these amazing animals. If a small portion of the spotted film that surrounds, or rather forms, the body of the animalcule be examined under more intense magnifying powers (fig. 46, A), every speck that dots its surface is perceived to be a perfectly-formed animal—a *Monad;* so that the envelope of the Volvoces is but an assemblage of Monads, united into one community by the intervention of a sphere-shaped membrane; and the cilia distributed over the surface of its exterior are the protruded mouths, or proboscides, of the individual component animals, all of which co-operate in giving the movements of rotation and progression to the globular mass of aggregated beings, precisely as the Gonium, described in a preceding page, was rowed about by a similar agency.

Yet even this is not all that Ehrenberg has shown to the astonished world relating to their structure! In each of all the hundred *Monads* that compose a Volvox, he has pointed out a complex organism; and if we criticise the names he has applied to different parts, it is not that we less appreciate discoveries so important.

In every speck, or Monad, he perceived the organs represented on an exceedingly large scale in fig. 46, B. The *Monad* itself consists of a transparent sac enclosing all its viscera, and of the following parts:—first, two tentacles, or proboscides *(f)*, that form

Fig. 46.



the hair-like organs projecting from the surface of the volvox; secondly, numerous sacculi *(b)*, or stomachs, as they have been named; thirdly, three contractile bags, or vesicles, two of which, in the figure, are marked with the letters *a*, *d*; and, fourthly, of a red spot (*c*), to which the name of *eye* has been, as we think, wrongly given. But, be the names right or wrong that are applied to organs so dissimilar from anything we know in animals superior in the scale of life to those we are contemplating, how can we express our wonder at a scene like this! An atom, almost imperceptible to unassisted vision, is composed of multitudes of beings, every one so complex in its structure as to be beyond the reach of our philosophy to understand!

The *Vorticella cyathina* is another exquisitely-constructed species, the history of which must not be lightly passed over. These beautiful animalcules, represented in fig. 47, resemble living wine-glasses, barely visible to the naked eye, but, under the microscope, forming most beautiful subjects for investigation. The body of the creature, or that portion which contains the digestive sacculi, and represents the bell of the wine-glass, is supported at the extremity of a long and slender stem, which is fixed to some foreign object, and, from its extreme irritability, can coil itself up in close spiral folds, or again elongate itself at pleasure. The mouth of the animal, corresponding to the margin of the wine-glass, is bordered with a fringe of vibratile *cilia*, which, forming by their movements strong currents in the surrounding water, hurry impetuously into the mouth whatever substances are used as food. Whilst active, and in search of prey, the Vorticella extends its stem into a straight line, directing its bell-shaped body towards the situation where aliment is most abundantly to be procured ; but if it is alarmed, with the rapidity of thought it twists its little stem into a spiral form, and thus shrinks from danger. Like the generality of the class under consideration, these animalcules

Fig. 47.

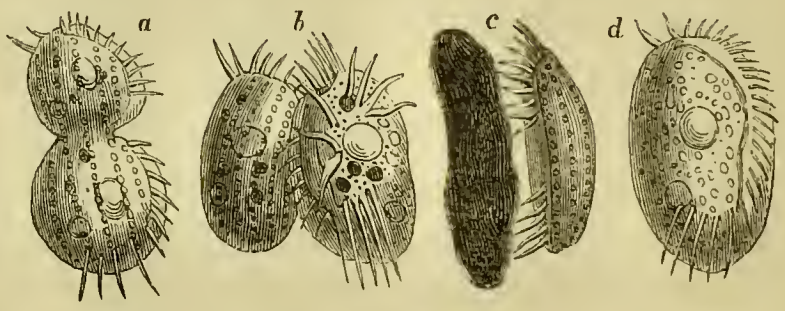
are reproduced by the spontaneous fissure of their bodies into two young animals; but, as some parts of the process are peculiar, we must here briefly advert to the manner in which the division is accomplished. Preparatory to dividing, the bell, or body, of the Vorticella becomes considerably increased in breadth: a fissure then appears, commencing about the centre of the mouth of the bell, and slowly extending itself downwards towards the insertion of the stem, thus separating the bell into two halves. One half sometimes becomes detached and swims away, leaving the stem fixed to the other half, which then continues to live as it did before; but more generally both separate from the original pedicle which in this case perishes. No sooner has the division been effected than the newly-formed bells, now stemless, present a totally different appearance; and, strange to say! locomotive cilia, that did not before exist, become developed at the end of the body opposite to the ciliary circle around the mouth! After being, for some time, thus endowed with locomotion, it, at length, finds a convenient station; sometimes a stone or plant; sometimes the surface of an aquatic insect; and, having chosen its place of attachment, it fixes to it the hinder part of its body, which it soon elongates into a new stem, and again assumes its original appearance.

The above given examples will make the reader sufficiently acquainted with the principal forms presented by these Infusoria, and serve to show that many of them possess considerable complexity

of internal structure. We have yet, however, to see, that, in various instances, external appendages are occasionally met with of very singular construction, whereby they are assisted in moving from place to place, or enabled to obtain their food with greater facility.

Some are furnished with stiff spines, bristles, or moveable hooks, wherewith they can crawl upon the surface of sub-aquatic plants on which they swarm in countless multitudes. On the *Trichoda charon*

Fig. 48.



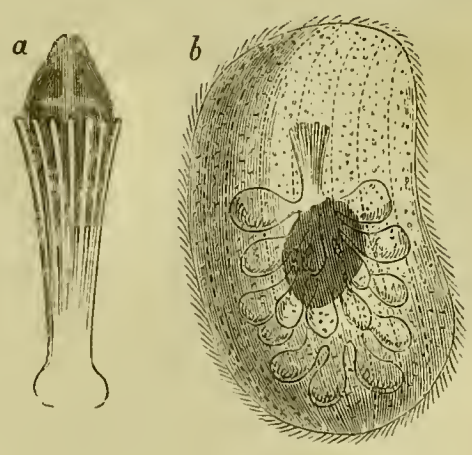
(fig. 48, *c*, *d*) all these organs are met with, some of them almost resembling legs on which the creature walks.

In the *Naviculæ* (fig. 43) the locomotive apparatus is of a different character, being composed of groups of excessively minute tubercles or suckers (fig. 43, *c*), by the agency of which such animalcules drag themselves along with a slow and almost imperceptible motion.

In the *Nassulæ*, a genus composed of several very beautiful species of Infusoria, Ehrenberg has discovered an apparatus of teeth, as he calls it, consisting of a cylinder of delicate horny fibres, sur-

rounding the orifice of the mouth, as represented in fig. 49, *b*, where one species, *Nassula elegans*, is represented entire. In the same figure, at *a*, this circlet of dental fibres is depicted on an enlarged scale, and an animalcule, seized by one extremity of the cylinder, is shown in the act of passing through it into the oral opening. Seeing, however, that the Nassulæ, like the generality of these creatures, are multiplied by spontaneous division, and separate into two new animals, a physiological difficulty presents itself of no trivial character, as it would seem that one or other of the young ones must be left without the teeth in question! Nevertheless, even this has been provided for in a very peculiar manner, since it appears that, previous to the division taking place, a new set of teeth is produced, so that the old *Nassula* has two sets of teeth developed; one for each half of its delicate body preparatory to their parting company and becoming two distinct beings!

Fig. 49.



But, unquestionably, the most important agents employed, either for progression, or for obtaining food, are the *cilia* placed upon the external surface of the bodies of most of the more active species of Infusoria; and, as we have already had more than

once to speak of these wonderful appendages, and shall, on future occasions, again and again, have to show similar organs performing very various duties, we will embrace the present opportunity of examining their nature and mode of action.

If the *Nassula elegans*, of which a drawing is given in the last figure, or any similarly-organized animalcule, be examined whilst alive, under a glass of considerable magnifying power, it will be perceived that the whole external surface of its body is covered with innumerable delicate, hair-like filaments, of indescribable minuteness, and that these hairs, or *cilia*, are continually in rapid motion; so that, by the combined movements of thousands of microscopic oars, the little animal is propelled through the surrounding water. Each individual cilium is seen, moreover, to have an innate capability of action, and stops, or moves, or works by itself, or co-operates with the rest, in complete subjection to the will of the animal. A question, therefore, very naturally occurs: What is the moving power whereby these multitudinous organs are made to act? And this question, it must be confessed, it is by no means easy to answer in the present state of our knowledge. Ehrenberg has, at different times, promulgated two theories in explanation of this curious movement. The first is, that every cilium is implanted by its base in a muscular ball; and the ball, having the power of rotating itself upon its own axis, moves the cilium at the same time, so that in its revolution it describes a cone, the apex of which is, of course, the base of the cilium. To

say the best of it, this is but a clumsy way of accounting for the phenomenon under discussion; and not very intelligible even were the movements of the cilium such as they are assumed to be.

But another suggestion of Ehrenberg's is, that around the root of every one of the cilia is inserted an apparatus of radiating muscular fibres, diverging from the cilium, as from a centre, and, consequently, able to pull it in any given direction. This were indeed to heap wonders upon wonders! We must, in this case, suppose that in animals themselves scarcely visible, not only are there these countless moving organs, the existence of which is only to be detected by the highest and most penetrating powers of the microscope, but that every one of them has a distinct set of muscles appropriated to itself! The mind revolts at so outrageous an idea, and is unable to believe such an explanation the correct one. Much more probable is it that these cilia are composed of a peculiar vital tissue, itself instinct with a power of motion. If muscular tissue, by its peculiar vitality, can contract and move itself, why should there not be a ciliary tissue equally able to move and contract itself without foreign agency, and, in like manner, subject to the control of the animal? Doubtless such a tissue exists, not only in the beings we are now contemplating, but wherever cilia are employed: even among the higher forms of creation.

The supposition, moreover, that, in its revolution, every cilium forms a cone, is not correct, as may easily be seen by examining these organs in a dying

animalcule, when their vibrations have become so slow and languid as to enable them to be observed with facility. It is to Dr. Arthur Farre that we are indebted for the best and most accurate description of the real nature of the ciliary movement. On examining the cilia that surround the oral extremity of the larger animalcules, which, by the rapidity of their movements, give the appearance of a wheel revolving upon the head of these creatures, as, for example, is the case in *Vorticella stentor* (fig. 50), that gentleman found each cilium, in performing its ordinary motion, bends itself at right angles to its base, and then rises again into a perpendicular position; and the wheel-like movement is explained in the following manner: — the cilia around the mouth seem to be arranged in the form of waves, or festoons, an appearance which is thus produced: the cilium at the base of the wave is laid flat, while that forming the centre, or highest point, stands erect, and the intermediate cilia present progressively every gradation of flexure from one to the other condition. But whilst the cilia are in rapid action, before the eye has had time to observe these circumstances, everything has

Fig. 50.

become changed! the cilium that was laid procumbent has again risen upright, and that which was previously in the centre of the wave has laid itself flat; so that the eye is beguiled by this constant movement, and the whole circle of cilia has the appearance of a revolving wheel.

Lastly, upon the surface of many species of these Infusoria one or two minute red spots are visible; and these, although so excessively minute as to require the very best glasses to detect their presence, are, nevertheless, constant in their appearance and relative position. What are these red spots? Ehrenberg says they are eyes; science echoes the term, and, from one end of Europe to the other, those physiologists who make theories founded on the opinions of others, tell us that here we have the first appearance of eyes in the animal creation! But what claim have they to be called by such a name? An eye can be of no use to a creature that has no brain to receive, or nerves to convey, information derived from that eye! and no one has pointed out the existence of such organs in the Infusoria. Neither have these specks the organization of eyes, nor resemble eyes in any particular, except that they are red. Moreover, it is not pretended that those animalcules that are without such spots, are at all inferior to those that possess them. Now, seeing that, according to all principles of modern physiology, we could not expect to find eyes thus low in the scale of animals, and as no proof can be offered that these organs are connected with vision, why should red spots so hastily be pronounced eyes? Surely it

is enough in the present state of science to indicate the existence of such appearances, and leave to time and future observation the development of their uses.

Thus are the waters densely filled with living atoms, and the very drops of all our stagnant pools are worlds profusely peopled! How can man contemplate such a scene and not be lost in wonder and amazement?

CHAPTER VII.

STERELMINTHA.

We turn, almost astounded, from the overwhelming scene presented by the animalcule world, but only to encounter one still more surprising. Surely, we are tempted to exclaim, Omnipotence can go no further, or more lavishly pour out existence on this earth than we have proved He has done!

Alas! how petty and how circumscribed are all the thoughts of man! how little does he see or understand of the grand scheme of Nature! We vaguely apprehend a beauty and a grandeur in the works of the Most High, but shut our eyes, and will not recognize the stern majesty with which His purposes are carried out, when what we witness jars with any of our preconceptions. Wherever life can be supported there are living beings placed. No matter what the difficulties, what strange localities present themselves to be inhabited, much less what human prejudice may think; the fiat has been issued and most strictly executed.

But here we pause involuntarily to ask what new localities may yet be found adapted to receive creatures so humble as the races we are now contemplating, or to afford them nourishment. As yet,

being unendowed with sense or locomotive strength, such animals cannot be placed on earth or in the air, and we have seen the water filled already so profusely that the mind almost refuses to believe the facts our senses and our microscopes reveal. Where else can they be placed? As though the external world, vast as it is, were all too small to satisfy creative power, room has been made in the interior of living beings, and there we find another world exhibited, not peopled sparingly, not occupied by accident, or, as our prejudice would say, in consequence of some mistake in Nature, some disease, but filled by countless forms of life as wonderful in their construction as the creatures we have hitherto considered; and, in variety of shape and aptitude for the strange situations that they occupy, not less conspicuous.

Let not our readers therefore shrink from the survey of the great class of animals which now awaits our notice, for assuredly they were not made in vain, but for wise ends; and uncouth and uninviting as they may appear to the rude eye of ignorance, we soon shall find that every one of them exhibits that perfection of design stamped on the rest of Nature's works.

The STERELMINTHA,* indeed, form but a small proportion of the extensive group of beings destined thus to lead a parasitic life, to which has been applied the general name of ENTOZOA, i. e. animals appointed to reside in the interior of other creatures. Other

* The *Vers parenchymateux* of Cuvier, so called from the soft and pulpy texture of their bodies, which are, for the most part, not hollow, στερεὸς, solid, ἕλμινς, a worm.

tribes will be described hereafter, which are organized on higher principles, and thus distinct in structure from the humbler forms it is our duty to examine next.

The *Entozoa*, as their name imports, are formed to occupy the substance of some other creature, from whose juices they imbibe their food, which is, of course, already animalized and fitted for their nutriment. All apparatus, therefore, requisite in other creatures to digest or to prepare the substances on which they feed are here not needed, and accordingly may be dispensed with.

Confined within a narrow space from which it is impossible to move, it would have been quite useless here to give organs of locomotion or even muscles such as must exist in higher forms of being; the *Sterelmintha*, therefore, are not endowed with any moving organs, but must be content to fix themselves and grow throughout their lives imprisoned in one spot.

For the same reason it is evident that senses would be useless where the animals possessing them could not by possibility hold any intercourse with the external world. Of what use would it be to furnish eyes, or ears, or taste, or smell, to creatures that must pass their whole existence closely shut up on every side without the power to stir? to which the light could not by possibility obtain admission? where sound could never penetrate, or if it did would bring but little information? Even to select their food could hardly here be given: if they have the general sense of touch, the consciousness of being, this is all

that may be granted, and perhaps even these are scarce permitted to such humble beings.

But though reduced thus low, thus destitute apparently of all enjoyment, let us not suppose them unimportant in the general scheme of Nature, though to human blindness, perhaps, it may seem hard to indicate their uses or their duties. Man, selfish man, regards them but as scourges sent to punish and annoy; yet surely this cannot be their sole office, else why are they found to exist in such abundance? Why such numerous forms distributed so largely through creation, that from the humblest animalcule up to man, creation's lord, no creature seems exempt from being at times inhabited by races that would seem specially appointed to infest the animals wherein they are found? The naturalist who with his microscope pores over the structure of those little beings that from their very smallness seem to elude his scrutiny, finds, not unfrequently, within their bodies, parasites of size proportioned to their bulk, and rising hence through every group of animals, zootomy has proved how universal is their presence.

Even in the same animal it has been found that every tissue nourishes a special race. One form is always met with in the brain, another in the liver, a third frequents, invariably, the fat, a fourth lives only in the muscles, a fifth selects the kidney, a sixth the lungs, a seventh the stomach; some abound in the intestinal tube, and some luxuriate in the blood-vessels themselves, nor ever interfere with the localities preferred by other species.

With evidence like this before us, who can doubt

the *Entozoa* to have been designed to occupy the stations where they are found? But let us now proceed to examine them more closely, selecting only such as will exemplify their various forms, their structure, and their appetites.

The first and simplest animals belonging this class, if animals indeed they be, are frequently met with abundantly in the bodies of man and of many ruminating quadrupeds closely imbedded in the substance of the liver or other abdominal viscera, and offer one of those examples of exceptional organization which the zoologist hesitates whether to receive into the animal series or not, notwithstanding the locality in which it resides. The *Acephalocyst*, for such is the name of the creature in question, when removed from the cavity in which it was reared, is a simple globular bag of very variable dimensions, composed of a thick, laminated, semi-transparent membrane, filled with an albuminous fluid, somewhat resembling the white of an egg. There is no head or mouth, so that when confined in its native cell, the only way in which it can be nourished is by simple endosmosis or the imbibition of surrounding fluids through the bladder-like coats of its body. It has no power of moving, neither does it shrink or contract when irritated, so as to indicate the possession of the slightest feeling. When it has arrived at certain dimensions, little opaque dots become visible, studding its surface; these are *gemmæ*, or buds, of future animals which, as in the case of the *volvox* described in a former chapter, grow between the layers of the integument or cyst that forms the creature's body till they ac-

quire a certain size; they then break loose into the cavity of their parent, where they increase in size and repeat the process of gemmation, their offspring breaking loose into the interior of their bodies, so that successive generations exist encased within each other like nests of pill-boxes, whence the name "Pill-box Hydatid," whereby these creatures are distinguished. Such a mode of reproduction is, indeed, not a little puzzling, seeing that it is difficult to understand to what end the new gem-formed races of offspring are created. In some genera, however the *gemmæ* are cast off externally, and then, of course, become independent of their parent.

The next species we shall notice is, however, distinctly an animal, although almost as simply organized as the last. It is at least a *stomach*, and consequently comes up to the definition already given of the simplest animal really entitled to that appellation.

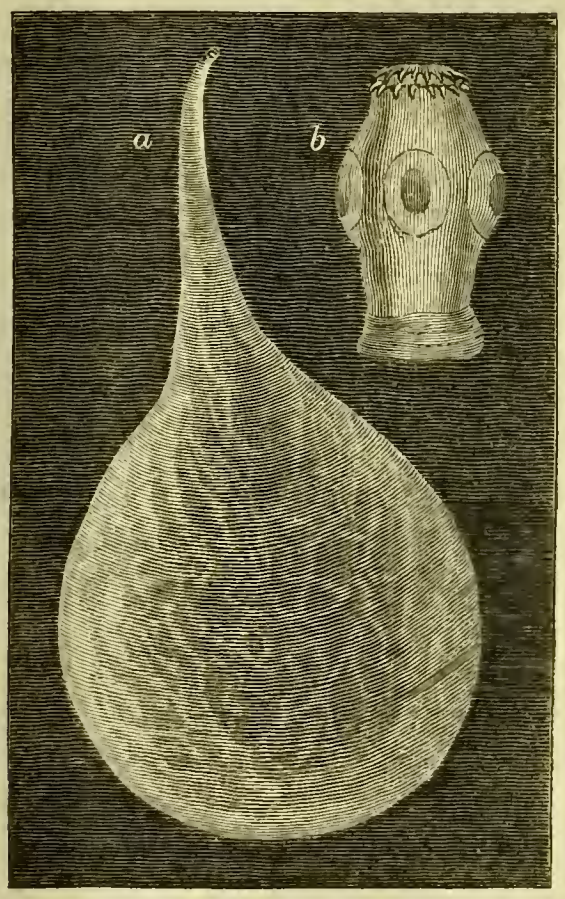
The *Cysticercus*, (or bladder-tailed animal,) is met with in many quadrupeds, more especially in pigs and ruminants, growing amongst the fat or intermuscular cellular tissue, and sometimes multiplying in such situations to a prodigious extent.

Its shape (fig. 51, *a*) is that of a Florence flask, the walls of its body being extremely thin and semi-transparent, filled internally with a clear albuminous fluid, and when irritated manifesting a slight degree of contraction.

It is only necessary to cast a glance at the figure of *Cysticercus* given in the next page, to perceive that it is a stomach or digestive bag, furnished with a mouth wherewith to fill itself with animal juices

derived from the cavity wherein it is immersed, and the only thing required is to construct this mouth upon such principles as will enable it most efficiently to obtain the nutriment on which it lives. Nor has this part of its economy been left uncared for, as we now proceed to show. The creature's head, exhibited on a large scale in fig. 51, *b*, is furnished with two sets of instruments whereby to hold itself where food may

Fig. 51.



be procured most plentifully. The mouth itself appears to be a simple aperture surrounded with a double circlet of minute recurved hooks, adapted both to anchor it securely in a given place, and by

its irritation to secure a flow of juices to the part, on which the entozoon may subsist. A little lower down are seen four oval suckers, equally adapted to lay hold on a smooth surface: thus secured, the *Cysticercus* sucks and grows continually, until perhaps the creature it inhabits, exhausted by the numerous parasites it nourishes, falls sick and dies.

The mode in which the *Cysticerci* multiply resembles that of the *Acephalocyst* already mentioned. *Gemmæ*, or buds, sprout forth from its envelope which, as they increase in size, break loose, and thus become in turn the parents of another progeny.

The *Cysticerci*, as we said before, are frequently diffused throughout the body of the animal infested by them, having been found lodged in the eyes themselves; hence several puzzling questions naturally arise which will require brief notice. In the first place it may be asked, how do they gain admission to their curious domicile? Are they formed as some have even been tempted to surmise, in the localities where they are met with, or are they introduced from the external world into the nidus where they are matured?

That they are formed by a diseased action of the parts around, and grow like certain tumours might indeed be possible if they were all as simple as the *Acephalocysts;* though, even in that case, it would be difficult to see how, when the cyst was formed, the vital power was given to bud and propagate as we have seen those simple beings do; but in the *Cysticercus* by what chance or morbid action could the curious mouth be given, so beautiful in its con-

struction and so well adapted to the wants of such a parasite; few, we should think, would feel inclined to grant disease the power of making such an apparatus.

That they are introduced from the exterior it is hard to admit. Are there the germs of *Entozoa* floating round us through the air, or are they lurking in our pools, our streams, our food, ready to take advantage of admission to a proper place, where they may grow and multiply? If so, how is it that they are not found in every creature of the species they frequent? for all appear alike within their reach, though they themselves occur so rarely, and when they are met with seem rather companions of disease than calculated to reside in healthy individuals.

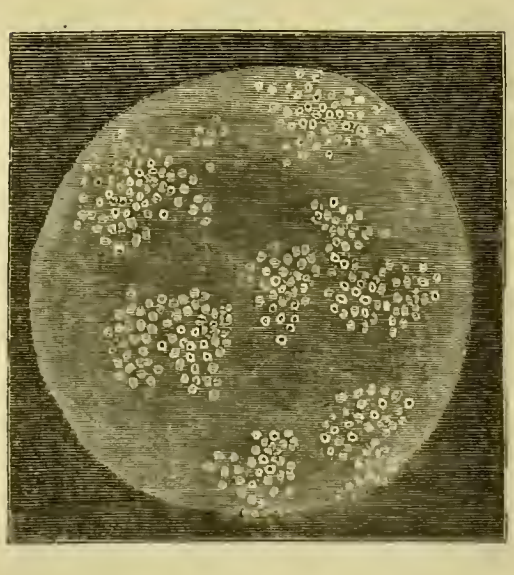
Again, when growing in the body of an animal, being multiplied, as we have seen, by buds, or *gemmæ*, how are they diffused throughout the system? Does the blood take up their nascent germs and hurry them from place to place till they are lodged in some fit spot where they may be developed? These queries, and a hundred more of the same tenor urge themselves upon our notice, but alas! our means of answering them are small indeed; they are among the mysteries of Nature, and perhaps will long remain inexplicable problems.

The *Cysticerci*, as has been explained, are simple stomachs without any superadded organs of sense or motion, but still able to assimilate nourishment imbibed through a single mouth of very curious construction. The next form of *Entozoon* that occurs for description, although obviously allied to the

former in the general features of its economy, differs in this remarkable circumstance, that, instead of being provided with a solitary mouth, the bladder-like body, resembling that of *Cysticercus*, is nourished by numerous mouths, all constructed upon the same principle, and all capable of ministering to the sustenance of the animal, so as to remind us once more of the alcyons, or compound polyps.

The *Cœnurus cerebralis* (fig. 52) is invariably met with in the brain of sheep, oxen, and other ruminating quadrupeds, where it sometimes grows to the size of a small orange, and, as it enlarges, causes, of course, dangerous pressure upon the substance of the brain. The animals in which this parasite takes up its abode speedily manifest the serious symptoms, indicative of their disorder: they grow dull and listless, refuse to eat, and soon begin to stagger in their gait, or turn round and round until they fall into an apoplectic condition that very quickly terminates in death.

Fig. 52.



The body of the *Cœnurus* differs in no respect from that of the genus last described, neither do its mouths, as far as relates to their mechanical construction, although, perhaps, from one to two hundred of them belong to a single individual. In the annexed wood-cut

(fig. 53,) three of these mouths are exhibited on a large scale, and in different states of protrusion, the central one being fully exerted and ready for use.

A slight inspection is sufficient to show the identity of the two structures; the mouth, with its apparatus of horny hooks, is precisely similar in both cases, as likewise are the sucking discs, placed beneath it, so that when we consider the multitude of these organs, and how impatient of injury is the brain wherein such creatures reside, we are not at all surprised at the speedy termination of their victim's life when once they are located in a proper situation.

Fig. 53.

These creatures, like the *Acephalocysts*, are multiplied by *gemmæ*, the young buds being hardly half a line in length whilst appended to the external envelope of the parent animal.

The next examples that occur as we ascend from simpler to more complex forms of these creatures, although they do not live in the *interior* of other beings, are so obviously organized after the manner of the *Entozoa*, that they can only be regarded as forming a part of the series we are now discussing. These are invariably found fixed to the skin of a soft-bodied mollusc common in the Mediterranean,

called the Thethys, the integument of which, from its texture, is quite as well adapted to supply them with fit nourishment as the internal structures of other animals; another proof, if any were wanting, how carefully Nature has turned to account every source whence sustenance could be derived.

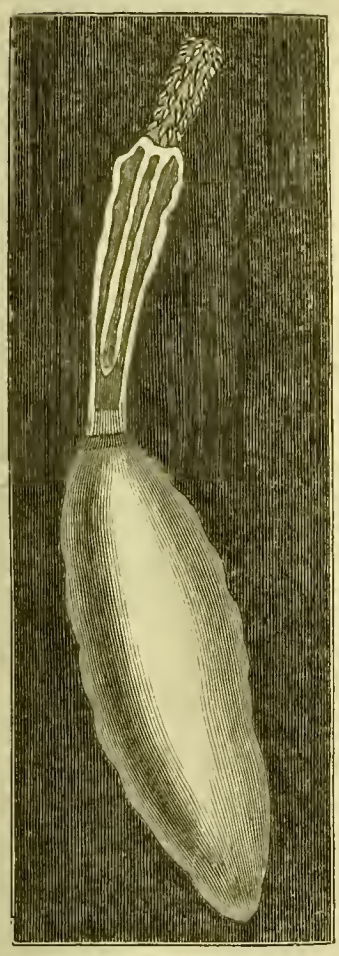
The *Vertumnus thethydicola*, the parasite in question, is a creature nearly three quarters of an inch in length, and of a somewhat pear-like shape, furnished at its larger end with a capacious sucker, whereby it adheres to the surface of its victim; and so exactly is the exterior of the body of the *Vertumnus* coloured to represent that of the creature upon which it lives, that many a practised zoologist might again and again examine a thethys so infested without doubting for an instant that the parasite was a part of the body of the molluscan.

Upon a splendid specimen of the thethys brought by Professor Forbes from the Mediterranean, and now in the museum of King's College, although the mollusc itself is not above six inches long, no fewer than three of these *Vertumni* were attached to its exterior. From their size and apparent importance the comparative anatomist might easily be led to expect a corresponding perfection of internal structure, instead of which, they are found to consist internally of a soft pith, something resembling that found in the shell of a very young hazle-nut before the kernel is developed,—a mere cellulosity nourished by juices prepared for it by a creature of far superior organization, but able to send forth the germs from which are produced another race as simple in con-

struction, and destined to imbibe food from the same source.

Differing from the *Cysticerci* in the construction of the mouth, though allied to them in the external appearance of the body, is the *Entozoon* represented in the contiguous woodcut (fig. 54). The suckers upon the head are here, as will be seen, replaced by organs of a different and even more formidable construction,—a long proboscis covered with sharp spikes, can be protruded from the creature's neck at pleasure, wherewith to root among the sluices whence its food proceeds, or hold tenaciously wherever a supply can be procured.

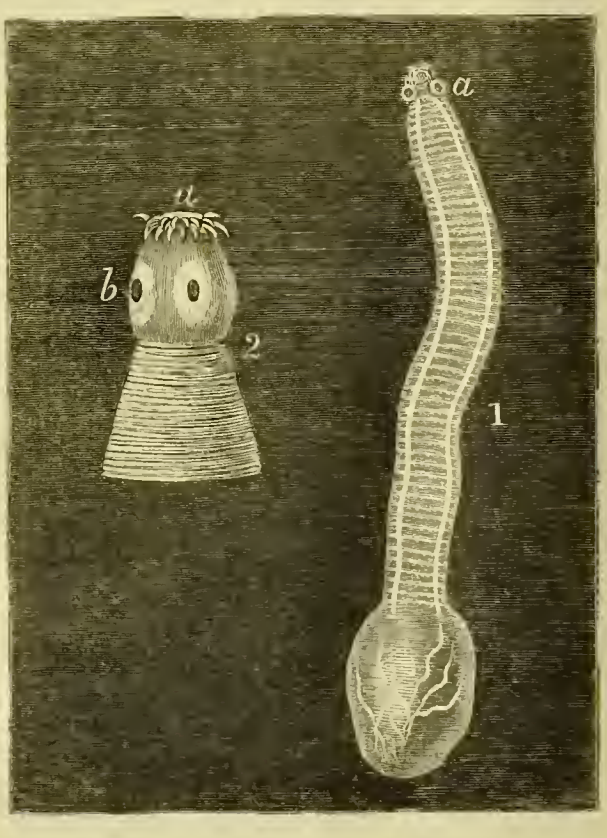
Fig. 54.



Throughout all the animal creation we perceive that Nature advances gradually from one type of structure to another, gliding, as it were, through intermediate conditions, both of outward form and internal organization. The next family of *Entozoa* the *Tæniæ*, or *tape-worms* as they are not inaptly called, are known by their elongated bodies, divided into joints or segments, and apparently very widely removed from the bladder-like *Cysticerci*. Nevertheless, there are gradations of being interposed between creatures of such different conformation as these two races, not belonging exactly either to the

one or the other family, but combining the characters of both. Of such, most evidently, is the *Entozoon* of which we here give a figure, the *Cysticercus fasciolaris*, (fig. 55, 1.) The mouth of this worm (fig. 55, 2) is at once seen to be constructed upon the same principles as that of the proper *Cysticercus* figured in a preceding page. The same double circlet of horny hooks surrounds the opening of the mouth (fig. 55, 2, *a*), for the purpose of fixing it

Fig. 55.



firmly in a proper situation for procuring the juices upon which it is nourished, while suckers (*b*) of precisely similar conformation to those of the Hydatid, are placed upon the lateral aspects of what we are naturally tempted to call the creature's head. The

long and attenuated neck of the *Cysticercus* is here, however, exchanged for an elongated body divided transversely into segmental portions that forcibly remind us of the appearance of a tape-worm; while the hinder extremity of the animal swelling out, as it does, into a delicate transparent bladder, proclaims a relationship still maintained with the simpler forms of the bladder-like *Entozoa*.

Infinitely diversified are the productions of the animal kingdom, as though to convince us of the boundless resources of the Creator, and to testify his power exemplified as much in the variety of his creatures as in their individual adaptation to the circumstances under which they are severally appointed to exist. How many strange variations have we already encountered, not only as relates to the external forms of the different races that have successively passed in review before us, but even as regards the fundamental principles of their construction! In the sponges we found millions of mouth-like apertures admitting nourishment into all parts of the body, while in the *fungiæ* no mouth whatever is to be detected, yet nutrition is accomplished in both cases with equal facility. In the compound polyps, hundreds of mouths minister to the support of one common body, which thus receives support from countless sources, the co-operation of which seems to be required in consequence of the precarious circumstances under which creatures so organized have to catch food supplied fortuitously from the surrounding water. But in the class now under contemplation, where nutriment already prepared and

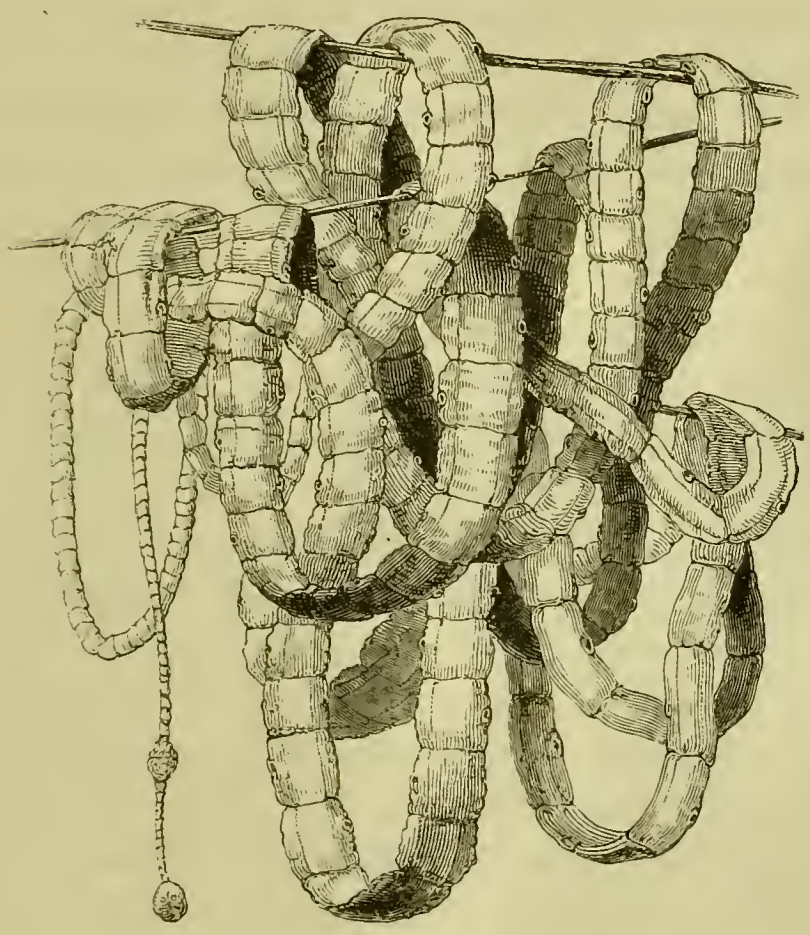
animalized is abundant on all sides, where even the labour of procuring it is almost dispensed with, and the *Entozoon* has nothing to do but to imbibe aliment as a plant sucks up the materials for support through its root, such elaborate mechanism is totally unnecessary; nay, so entirely is the system changed, that we find in the next group that offers itself to our notice, hundreds of bodies nourished by a single mouth, and, moreover, obtaining from this source ample means of subsisting at the expense of the unfortunate beings who are compelled unconsciously to regale such multiplied voracity.

Here, however, as in every other case, the multiplication of similar organs in the same animal argues a very low and imperfect type of structure, and forcibly reminds the naturalist that we are not yet very far removed from the vegetable kingdom.

The entire family of *tape-worms* are constructed in accordance with this inferior plan. Their bodies consist of a repetition of similar segments, every one of which would be entitled to be considered as a distinct animal, except from the circumstance that a single mouth is sufficient to supply nourishment to the whole series, however long. These *Entozoa*, whose structure is perfectly unique, there being nothing resembling them elsewhere in the whole animal creation, take up their residence in the alimentary canal of various vertebrate animals, and thence derive an abundance of food fully sufficient for the support of their enormous bodies, which in some species have been known to attain the very great length of sixty or even a hundred feet, and to consist of five or six

hundred joints connected together. The *Tænia* figured below, (*Tænia solium*, or solitary worm,) an *Entozoon* that infests the human race, will serve as an example of the structure of the whole tribe of these singular beings. The joints as they approach

Fig. 56.



the head become extremely small, forming a kind of long attenuated neck, upon the end of which is placed the head, an organ formed for taking a firm hold to fix the mouth in situations proper to afford a due supply of food.

Essentially, the structure of this head resembles

that of *Cysticercus* heretofore described. The mouth is in the centre, a small orifice surrounded with a double coronet of horny hooks, and likewise furnished with four sucking discs to ensure a more tenacious grasp. But it is evident a head like this, supported on a neck so slender would be quite unable to ensure secure attachment for the enormous body it is destined to support; additional and firmer anchorage must therefore be provided: this provision has accordingly been made. Upon the margin of each segment has been placed a strong and prominent sucker, so constructed as to adhere with a firm gripe to the smooth walls of the intestine where the creature has established its abode: every joint is, therefore, safely fixed *in situ*, and it thus becomes no easy matter to dislodge a worm like this from all its numerous anchorages.

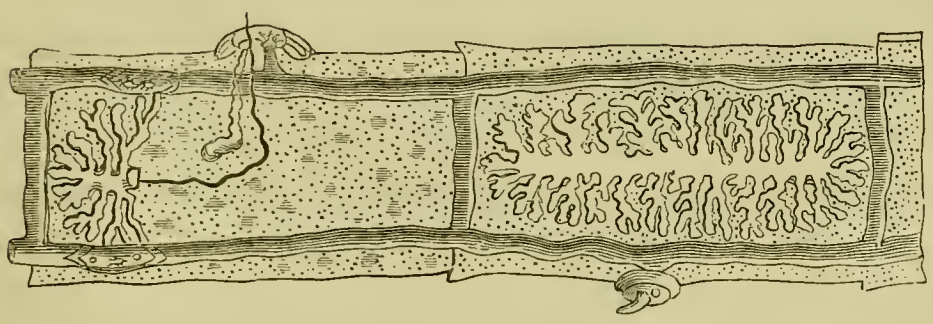
Extending from the mouth, two nutritive canals pass backwards through the body, reaching quite from end to end, passing along the opposite margins of each segment as represented in the appended figure, (fig. 57.) At the commencement of each joint these two canals intercommunicate by means of transverse branches, a provision, doubtless, to ensure a free supply of food to every part, which, being thus conveyed through all the joints, the worm, however lengthy, is nourished without difficulty, and even without exertion on its part.

But the most astonishing circumstance connected with the history of these tape-worms is their unexampled fertility. Every segment of a *Tænia*, as has been already stated, is a complete animal, except

as regards the manner in which it is nourished. The proof of this is, that in every segment is situated a complete apparatus for producing eggs, and that quite independently of all the other segments.

On reference to the figure (fig. 57) the nature of this structure will be readily understood. Occupying the whole of the central portion of each joint, and surrounded by the nutritive canal, is situated a very extensive group of short branched tubes, all diverging from a kind of central stem, something resembling the trunk of a tree. At certain periods all the ramifications of this organ, as well as the

Fig. 57.



central cavity, are found stored with great numbers of minute granular bodies of a brown colour, amounting, at a very moderate computation, to several hundreds. Every one of the minute grains referred to, upon examination, is found to be an egg, so that hundreds of eggs are periodically produced in every joint of which the tænia may consist, and these when mature, escape out of the body of the worm through pores placed in the marginal sucker. The number of eggs, therefore, that emanate from a single tape-worm must be prodigious; for, allow-

ing only five hundred to be derived from any given segment, (a very moderate calculation,) and the worm to consist of only a hundred joints, we should have a progeny of 50,000 produced in a season. A precious legacy to the world to be bequeathed by a single *Tænia*.

On the other hand it must be observed that, fortunately for other animals, the parasites in question are but rarely met with, and when they are found to exist, so unusual is it to find more than one inhabiting the same individual, that the name of "solitary worm" applied to the species we have been describing owes its application to this circumstance. Seeing, therefore, the enormous disproportion that exists between the number of eggs produced and the rarity of the animal producing them, we are naturally led to inquire—what becomes of the eggs? Do the progeny resulting from them exist external to the body under some other form more familiar to our eyes, which only takes upon itself the growth and character of the tape-worm when introduced into a locality where high temperature and abundance of food promote a monstrous growth? Linnæus, indeed, believed that these creatures were, under humbler dimensions, constant inhabitants of marshy grounds, and only needed more abundant nutriment to call them to their full developement; but no observers since him have had reason to confirm this notion. Moreover when we see their lateral suckers and the whole construction of their bodies fitted for the parasitic life they lead we hardly can believe them destined to a different mode of existence.

Others assert, that germs so multitudinous are cast into the world because the probabilities are small, that out of millions even one or two shall find by accident a proper dwelling-place. It may be so—we know not—nor is it easy to conjecture on the one hand why such care has been bestowed to make them thus prolific, or on the other, seeing their numerous eggs, how Providence has so restricted their pernicious increase. Among the lower animals likewise these creatures are abundantly distributed, though somewhat modified in form and variously armed about the head, according to the place on which they have to grapple. Some have their heads divided into lobes, on which are placed sharp prongs—real tridents—to infix and firmly plant within the viscera of their poor victim; such are met with in the perch and pike. Others have branchy horns upon their heads all covered over with hooks; these too are found in fishes. Still in all essential points their structure is the same; we therefore will pass on as rapidly as is consistent with our subject.

Sheep, when confined in wet and marshy pastures, are, as the farmer too well knows, subject to a disease most usually called "the rot," which frequently commits sad havoc in his flocks. The cause of this destructive malady is found to be an *Entozoon* of another kind, to which the name "fasciola," or "fluke" has been applied. This creature occupies the liver, not of sheep alone, but of the horse, the hog, and many ruminating quadrupeds, where it revels in abundant stores of food adapted to its nourishment. Leuenhöeck asserts that he has found

as many as eight hundred and seventy of these parasites inhabiting a single sheep, a number quite sufficient, as we may suppose, to cause a little indigestion.

In shape the fluke resembles a sole, about an inch in length, its body being composed of a soft whitish substance. On its under part are placed two broad round sucking discs, one situated near the middle of its body, being an anchor destined to secure firm hold on the surrounding parts; the other placed in front, forming the mouth, through which, as by the assistance of a cupping-glass, the food, already fitted for nutrition, is sucked into the creature's body, there to be conveyed by arborescent tubes through every part. These creatures, like the last, are most remarkable for their fertility. Their bodies are frequently filled with countless eggs, which, if they all were made productive, would, from their very numbers, make the flukes most dangerous and formidable pests, for few if any cattle could apparently escape their ravages. But here, as is the case with other *Entozoa*, it does not seem that animals in health are readily obnoxious to the persecution of such parasites. It rather would appear, that weakness and debility favour or tempt their presence, as though they were the silent ministers of fate, appointed, constantly, to lurk in ambush till a fitting victim comes to tempt them from their inactivity.

The race of flukes, however, must not be supposed to limit its attacks to flocks and herds: these creatures are distributed as widely as the rest,—and beasts, birds, reptiles, and fishes, all have forms appointed

specially to take up their abode in different species fitted to receive them. But these we pass in silence, lest our catalogue extend beyond what patience will endure to read.

There is some reason to suppose that the *Fasciolæ* may live in marshes in a less conspicuous form, and only acquire their full developement when they by accident obtain admission to a lodging stored with plenteous food. Certain it is, that almost every ditch contains examples of a tribe of animals so nearly similar that, although they are not parasitic in their habits, but frequent standing and running waters, they must here be noticed as belonging to the *Sterelminthoid* worms.

These are called PLANARIÆ, and are met with in great numbers on the weeds and floating vegetation in all stagnant pools. In shape they much resemble little leeches, of a blackish hue, and are rarely more than a few lines in length. Internally their structure is almost identical with that of the *Fasciola*, presenting both the same arrangement of the nutrient tubes and the same numerous eggs. Still in some points they are peculiar, and require a little of our notice.

First, as regards their food and mode of catching prey. These creatures, notwithstanding their apparent helplessness, are found to live on worms or insect larvæ; neither do they scruple much, if other prey be scarce, to eat their fellow-creatures. To accomplish this, the little cannibals are gifted with a very curious kind of mouth, one, indeed, which has no parallel in any other race of beings. This mouth consists of a long fleshy funnel, plaited like a fan,

which can be folded up or spread abroad at pleasure. Should a worm approach, this funnel is unfolded and applied around the body of its prey which thus retained, in spite of all its struggles, is soon sucked and emptied of its juices.

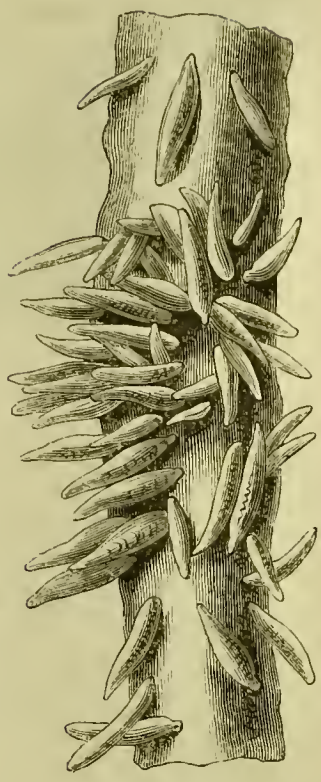
Another circumstance connected with the history of these animals worthy of mention, is their great tenacity of life. If a *Planaria* be cut in two, so trifling does the occurrence seem, that either part moves on as if quite unconscious of having lost its better half, and straightway can repair the little inconvenience thus produced, the missing portions soon growing again.

Nay, sometimes they divide spontaneously into two animals, each of which, perfect in all its parts, evinces all the powers of the original being.

To change the scene once more: we now approach the highest of these *Sterelminthoid* worms, provided, it would seem, with still increasing power of doing mischief. These are called *Echinorynchi*, (ἐχῖνος, a hedge-hog, ῥύγχος, a proboscis,) so named because their mouths form a protrusible proboscis, armed all over with strong hooks or spines, which, being deeply plunged into the viscera, from whence these creatures suck their food, retain a firm and most tenacious hold, as may be judged from the annexed figure, (fig. 58,) wherein a party of these parasites is represented, all having their heads fixed in the sides of the intestinal passages in which they dwell. It happens not unfrequently, indeed, as might be easily imagined, that the creatures we are now considering are not superlatively nice about the depth to which

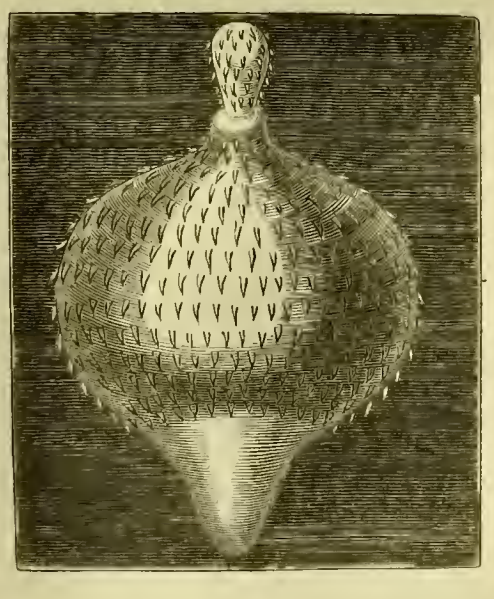
they bore in search of nutriment, and frequently by going a little way too far destroy the source of their supply, and at the same time end the sufferings of their victim.

Fig. 58.



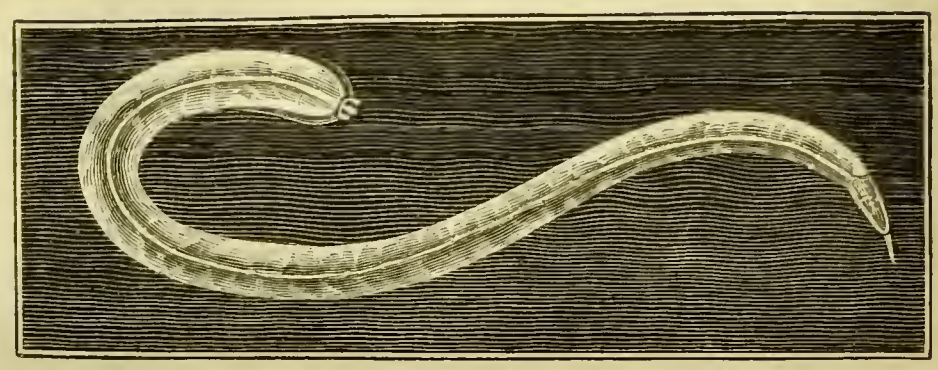
No doubt can here exist as to the intention with which creatures such as these were formed; yet even the dreadful apparatus they possess is sometimes made more formidable still, as for example in the *Echinorynchus*, shewn in fig. 59, where, besides the spiny-armed proboscis, all the circumference of the dilated body is seen studded over with sharp horny hooks, which fix like grappling-irons in the flesh, and seemingly defy all efforts to dislodge an animal thus firmly fastened in the domicile appointed for its residence.

Fig. 59.



At length the worm-like form is fairly given, and creatures organized after a higher type begin to be sketched out by Nature, even among these humbler parasites (fig. 60), that lead us on insensibly to another group of similar propensities but more exalted structure. The history of these must be

Fig. 60.



deferred to a more fitting place; enough has here been said to show that even the *Entozoa* of this lower group exhibit in their structure such design, such adaption of all parts of their economy to the peculiar sphere assigned them that they must be deemed essential portions of the wondrous scheme of the all-wise Creator.

We thus have run through all the various groups of *Sterelmintha* and found them not an unimportant class, but evidently organized on special principles, adapting them to the strange sphere in which they live. But let us now regard them in another point of view, and see how far they claim attention from their numbers, and the care with which each tissue of the animal frame has had fit occupants provided: but here one or two striking instances will serve our purpose.

Frequently within the last few years the muscles of the human frame, examined by the anatomist, have been observed to have a spotted look, seemed covered with small specks, as though they had been peppered from a pepper-box; and this appearance was remarkable in all the voluntary muscles through the body.

Examined with a microscope, each individual speck, each little grain, was found to be a vesicle resembling in its shape a soda-water bottle, scarce one fiftieth of an inch in length. Within this tiny flask, or cyst, was found a worm (*Trichina*), of corresponding size, coiled up living within its little prison, and imbibing there the juices that surrounded it. Now, in these instances, allowing but a hundred of such worms to be contained in every cubic inch of flesh, and this is a low estimate, how many thousands must have taken up their residence in the interior of the party so affected! Nevertheless, as far as could be ascertained, the individuals, whose bodies thus were made to harbour such innumerable hosts of parasites, during their lives had shown no sign of illness. They had lived in health, and died from very different causes,—some from disease, others by violence.

Yet even the *Trichinæ*, numerously dispersed, both through the flesh of man and various other animals, as they are found to be, fall short, both in their numbers and minuteness, when compared with other *Entozoa* discovered by my esteemed friend and colleague Mr. Bowman.

All the *Trichinæ* live in the interstices between the fascicles of fibres which compose the muscle that they occupy; but even the sheaths of the individual muscular fibres themselves, of which the primary bundles called muscular fasciculi are composed, sheaths so fine that they are difficult to discover, except by the assistance of a good microscope, are sometimes filled with living animals adapted to occupy even this extraordinary situation, and appa-

rently destined to feed upon the muscular substance itself. In an eel examined by Mr. Bowman, that to all appearance was in perfect health, plump and well fed, the muscular fibre in some parts of the body was found converted into a mere diaphanous tube containing numbers of minute parasitic worms, coiled up like the *Trichina spiralis*, and closely packed together. The sheath of the muscular fibre, (*sarcolemma*,) was quite entire, although all its contents seemed to have become the food of these *Entozoa*. At both ends of the delicate tube, where it had been broken off from the rest of the muscle, several of the little worms soon escaped from their confinement and began to show signs of life, uncoiling themselves, and moving about slightly in different directions with an undulating motion. Each was about one forty-fifth of an inch in length, blunt at one end, and tapering considerably towards the other. They contained in their interior numerous detached dots or granules of different sizes but without the appearances of complicated structure, whilst among them were many globular or oval bodies, nearly as large as the coiled parasites, and marked like them with minute dots. Some of these were evidently worms very compactly folded up, but in others no coils could be distinguished. These were smaller, and had the appearance of immature animals. The whole number of worms contained in this minute portion of muscular fibre Mr. Bowman found to be more than a hundred. What immense numbers then might have been contained even in the substance of a single muscle!

Here, perhaps, we might have closed this chapter, satisfied that we had said enough to prove to the most sceptical the truth of the assertion made at its commencement, namely, that living creatures have been placed wherever they could be supported, and that all living beings, high or low, may be recipients of some other animals destined to live within them. Still another fact remains to be recorded. Room may yet be found, and Nature, with a parsimony of space that seems to know no bounds, has framed appropriate occupants. But where is that? we naturally inquire. Can we go deeper than we yet have sunk? Have we not fathomed now the very depths of being, when we find that living bodies may themselves be worlds, peopled innumerably with parasitic beings? Not quite. The parasites themselves as yet remain to be tenanted, and we shall soon perceive that even they are not exempted from the general law.

Within a little parasitic creature met with in the perch, inhabiting the very humours of the eye, and which sometimes abounds to such an extent that the poor fish's eye-ball seems quite filled with them, (*Diplostomum volvens*,) a creature which itself scarcely exceeds in size the one seventieth of an inch—Nordmann observed numerous minute brown capsules, which, when opened, were found filled with microscopic beings, smaller in size than the smallest infusorial animalcules, but still alive and active.

Even the rude hydatids (*Echinococcus*) have within them other animals of very diverse structure, some of which are represented in the figure here annexed,

(fig. 61,) small vermicles that swim about at large in the contained fluid, as if the darkened space contained within the body of a bladder such as this could not be spared by Nature, seeing that even there special inhabitants have been located, and that by no means scantily as will be gathered from the following description of *Echinococcus veterinorum* given

Fig. 61.

by Professor Owen, who examined several individuals soon after they were taken from a recently killed animal, a pig, in which they existed in great abundance.

The bodies of the hydatids or containing cysts were composed of two layers, artificially separable, both of a gelatinous texture and filled with a colourless

limpid fluid, in which were floating a few granular bodies, together with immense numbers of extremely minute particles. On examining these particles with a high magnifying power, they were seen to be living animalcules, of an ovate form, moving freely by means of superficial vibratile cilia. On compressing the animalculæ between plates of glass, they were found to have a dental apparatus precisely like that bestowed upon some of the *Infusoria* described in a former chapter (vide fig. 49), with which most probably they ought in strictness to be classified; but whether these little beings be *Infusoria* or *Sterelmintha* has little to do with our present purpose, which is to show the extent of the animal creation in the direction we have now been prosecuting our examination of it, and form some faint ideas at least of the vast series of living beings,

> "Above how high progressive life may go!
> Around how wide, how deep extend below!"

Here, then, we close this chapter, the more willingly because it treats of disagreeable subjects for reflection. Let us refresh ourselves by turning to a new and far more lovely scene.

CHAPTER VIII.

ACALEPHÆ.

How welcome to the naturalist is the sea-shore, the boundary that divides two grand domains of Nature! How sweet to wander on the shingly beach and view the vast expanse of waters, feeling that it is in itself a world more densely filled with life than that we tread! What multitudes are sporting underneath those waves! What infinite diversity of forms are hidden there! Some exquisitely beautiful, adorned with perfect elegance and symmetry of shape, others of hideous mien and rude uncouth exterior, but all agents in one great scheme, blindly fulfilling duties that promote the general weal, and all concurring to produce one grand harmonious whole. No matter how dissimilar in their organization, or contrary in their habits; whether they be feeble, and apparently impotent, or gifted with strength and ferocity enabling them to domineer over their cohabitants of the realms of ocean; whether they be the tyrants or the victims in that wide warfare that is perpetually carried on wherever animals are found, they are alike mutually dependent, alike indispensable to the integrity of the mighty plan of Creation.

Who that has visited the coast has not observed, cast up by the receding tide, and left to melt and drain away upon the strand, huge lumps of jelly, upon which the passer-by scarce deigns to cast a look, except, perhaps, to wonder whence the rude mis-shapen mass could have proceeded. Perchance, attracted by its strange appearance, he is led to examine it a little more attentively and sees that it is organized, and, from its structure, seems to be an animal.

Fig. 62.

He takes it up, and wonders to perceive the regular arrangement it presents in every part, until at length, growing more curious to investigate its nature, he places it in some still seaside pool, the better to observe it. Soon its parts unfold and spread themselves before his wondering eyes, into a shape as beautiful and regular as that portrayed in the appended figure (fig. 62). An elegant transparent disc expands on every side, and floats upon the surface, while, from its lower surface, hang appendages of various kinds, so delicate in structure that they scarcely can be seen in the clear fluid where the creature swims.

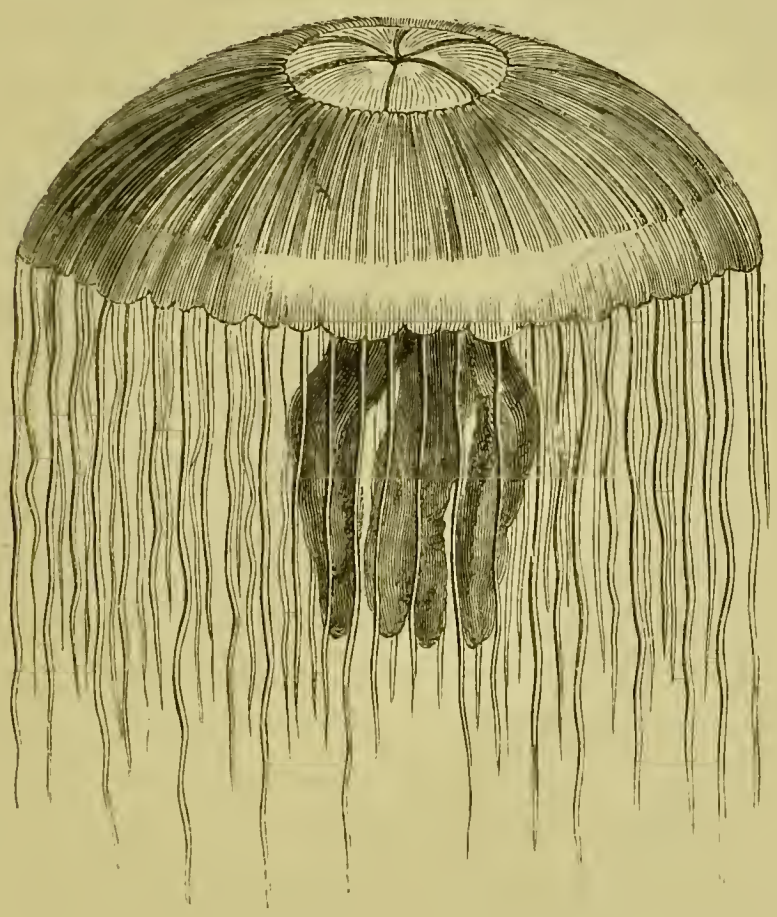
The Acalephæ, that great class of animals to which the creature just described belongs, are found in every sea and in all climates under shapes the most diversified; each we encounter seeming to excel the last in graceful form or in the nice contrivances employed in fitting it to occupy its destined sphere of action. One circumstance alone, and that a trivial one, has been selected as a character common to the whole group. Whoever handles them incautiously will find that, harmless as they seem, they have the power of stinging like a nettle. All nations seem to have had this fact impressed upon them; for, though the rude care little for philosophy, they all can feel a sting, and this, as being the most important feature to their minds in the whole history of the animals we are about to study, has given a name selected, as by one consent, to characterize the race. "*Urtici marini*," "*Orties de mer*," or, in the less euphonious dialects of our own country, "*Stang-fishes*," "*Stingers*," are the common names applied to the "*sea-blubber*" on the beach. The scientific word, indeed, employed by modern naturalists to designate the class means nothing more, being a Greek word (ἀκαλήφη) that simply signifies a nettle.

Commencing with those forms of *Acalephs* most usually met with on our shores, we now proceed to lay before the reader what is known concerning their economy, and doubt not that as we proceed with their strange history he will find cause enough for wonder and admiration.

The first group that we have to notice has been named by Cuvier, *Rhizostoma*, i. e. *root-mouthed*, of

which the common jelly-fish thrown up so frequently upon our coast is a well-known example. One of these *Acalephs* (fig. 63), consists of a large mushroom-shaped disc of jelly, measuring sometimes a foot across, from the centre of which depends a thick and massive pedicle that hangs quite loose among

Fig. 63.



the waves. If watched attentively while floating in still water, the expanded disc is seen to move itself in gentle undulations with a slow and even motion, something like the heavings of the chest during respiration, contracting and dilating at short intervals. These movements have the effect of rowing it about

from place to place while the sea is quite calm; but they are far too feeble to resist the action of the waves or wind, and, consequently, the *Rhizostoma* must float entirely at their mercy, and, should it come near land, is cast like a dead mass upon the shore.

The central fleshy stem is perforated over all its surface with innumerable pores, and forms a kind of root through which to imbibe such food as is adapted to afford the creature proper nourishment. Each pore, in fact, is the commencement of a fine canal, which terminates by joining others of like calibre, derived from neighbouring pores, to form a set of tubes of larger size, and these again uniting with contiguous branches, form, at length, large trunks through which whatever is imbibed by all the root-like stem is poured into a chamber excavated in the centre of the disc, to which perforce we must apply the name of stomach, seeing that there digestion is accomplished. The waves supply materials for support abundantly, even to animals so feeble and so helpless, for every drop of water, as we have seen in a preceding chapter, swarms with microscopic beings that are here employed to feed the unconscious *Acaleph;* for, as it swims about, its pendant root continually sucks up the invisible prey in countless myriads; no danger here of lessening the supply, which is as exhaustless as the sea itself.

Proceeding from the central cavity wherein digestion is accomplished, numerous large canals diverge and run like radii towards the margin of the disc, where they divide and subdivide until they form a net-work of fine vessels, copiously diffused through

the circumference of the animal. By these canals the food digested in the stomach is conveyed throughout the body and thereby the whole is nourished.

The movements of the *Rhizostoma*, whereby it rolls itself from place to place, are vigorous and easily discernible, but when we come to seek the moving power it is by no means obvious. The body is entirely composed of the same delicate, transparent tissue: muscles there are none, not even the microscope reveals a fibre worthy of the name. No nerves are visible, nor instruments of sense of any kind, except, indeed, the filaments sometimes suspended from the margin of the disc be looked upon as tentacles; yet thus the creature swims about, a living plant whose roots are in the ocean, not the ground.

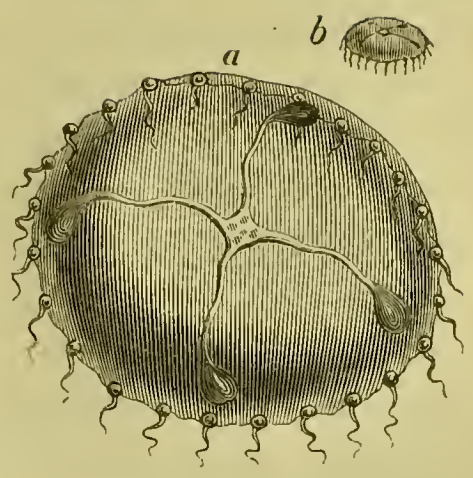
Yet helpless as these *Acalephs* appear, their uses in creation seem to be important. Not only do they serve as food to countless animals that hence derive their nourishment, but possibly the sea itself is fitted by their agency to be the residence of beings that otherwise would perish. Not the least striking circumstance connected with the history of the *Rhizostoma*, is its prodigious power of procuring from the surface of its body quantities of mucus, or thick slime, which is, of course, mixed up with the surrounding water. Whence this material is furnished is even yet a question; but so copious is the supply that if a specimen be placed alive in a large vessel filled with water, in a little time the whole is rendered thick and viscid, so that the *Rhizostoma* would perish speedily from the accumulation of its own secretions. You change the water, but in vain, still

the abundant mucus is poured forth, nor does it cease as long as life remains. But if a single specimen afford such quantities of viscid matter, we shall readily conceive, when we reflect upon the countless multitudes of *Acalephæ* spread through every sea, that their united agency must cause important changes in the water around them, filling it with animal substance upon which innumerable races may be fed, a kind of nutriment adapted to the feeble mouths of new-hatched spawn or ocean's tenderest progeny. Thus in the mighty scheme of Nature every race is made subservient to the general good, silently working, and too oft alas! unseen, unnoticed, and unknown, though showering blessings over half the world.

Such are the habits of the *Rhizostoma*, and such the food on which it lives, the only food the reader, doubtless, thinks, that possibly could be procured by the slow-moving, senseless, helpless, *Acaleph*. But let us take another specimen from the same group, and see if all are thus restricted to the humblest fare. The next forms that present themselves are named by naturalists *Medusæ*, of one of which a figure is here given (fig. 64). In shape and texture it appears to be a *Rhizostoma* without its pedicle, the mushroom disc without the stem, instead of which a mouth is given, a simple orifice placed in the centre of the under surface of the animal, which leads at once into the cavity that represents the stomach. Thus organized, the creature swims about, rowing itself along by gentle undulations of its soft transparent body seeking food. But what food can an

animal like this devour, so sluggish and so impotent as it appears? Incredible as it may seem, the strongest and most active races met with in the sea fall easy victims to these apathetic murderers. Crustaceans and Worms, Fishes themselves, in spite of swiftness and activity and strength and cunning, are seized hold of and overmastered. Being firmly grasped by the transparent disc of the *Medusa*, they are slowly forced into the creature's stomach, where they speedily dissolve and melt away, their solid substance disappearing in the soft transparent tissues of the *Acaleph*.

Fig. 64.



But how is this accomplished? by what means can a soft film of jelly, delicate and tender as the creature we are now considering, effect a capture that must seem to every one quite disproportioned to its feebleness? The stinging power above alluded to as forming such a striking feature in the history of the whole class is, doubtless, in this case, employed to aid in catching prey. No sooner does some passing fish but come in contact with an enemy apparently so despicable, than the pungent fluid seems to torpify and palsy all its faculties: it lays quite paralyzed and motionless, wrapped in the venomed folds of its destroyer, and at length is swallowed unresistingly.

This stinging property depends upon the presence of an acrid fluid that exudes from the whole surface of the creature's body, so caustic in its nature as to cause great irritation, even when applied to the human skin; nay, cases are by no means rare where the incautious bather, having come in contact with the floating masses of these animals that frequently occur, has suffered most severely from the pain and inflammation consequent upon the application of this living blister to the skin. According to some writers who have had the means of making observations on this subject, the irritating fluid will retain its potency for many days, so as render it unsafe to wash your hands in the same vessel that has been employed to hold these animals, or touch the napkin upon which they accidentally may have been laid.

The disc of the *Medusa* is surrounded with *red spots* disposed at equal distances around the margin, from each of which depends a little filament or tentacle. To these red spots Professor Ehrenberg, as usual, gives the name of eyes. Should they, indeed, be visual instruments, of which, however, not the slightest proof has been advanced, the *Acalephs* in question must be looked upon as being eminently endowed in this respect. Argus himself was scarcely better furnished, — and so conveniently disposed to see round the whole panorama at one glance! The only thing required to entitle these red spots to be regarded as true visual organs, is a structure something comparable to an eye, a structure which they unfortunately do not possess. No proof, moreover, is advanced to show that the *Medusæ*, furnished

with the spots in question, are affected by the light more powerfully than other genera where nothing similar exists. Why, therefore, call them eyes?

But although in this, as in other cases already noticed, we can by no means assent to the appropriateness of the name bestowed on these organs, we must on that account by no means omit to lay before the reader the result of Ehrenberg's researches connected with the portion of the economy of the *Acalephæ*, more especially as the anatomical facts recorded by the illustrious microscopist of Berlin have been, to a certain degree, substantiated by observations made upon other genera hereafter to be noticed.

In *Medusa aurita*, the species which formed the subject of Professor Ehrenberg's investigation, the eminent observer in question detected what he conceived to be a nervous system, composed of small ganglia situated in the vicinity of the oral opening, which seemed to be in correspondence with the groups of tentacula there situated; and in addition to these, he describes a nervous filament of great tenuity which runs entirely round the circumference of the umbrella-shaped disc placed close beneath the roots of the tentacula appended to its margin. Connected with the circular nervous cord last mentioned, are eight little masses of a brown colour, that consist partly of a glandular-looking structure, and partly of a brilliant red spot, to which last portion of the organ the name of *eye* has been specially appropriated, though upon grounds that appear to us to be anything but satisfactory.

That nerves should exist in some of the most elevated forms of the *Acalephæ* might indeed be naturally expected, seeing that the more highly organized members of this class, as of every other, begin gradually to approximate still more exalted races. This, indeed, is the case with all the groups of Acrite Animals we have as yet examined, in every one of which, before the acrite type is entirely dispensed with, traces of nerves begin to make their appearance, as an organism more nearly allied to that of a superior class begins to develope itself, softening off, as it were, one form of life imperceptibly into that which immediately succeeds it. There are no sharp lines or trenchant boundaries of separation met with in the animal series, else would the labours of the naturalist become comparatively light; and the consequence inevitably must be, that all systems established for the convenience of the zoologist, although they may be true in their grand principles, fail to be of universal application in their minute details.

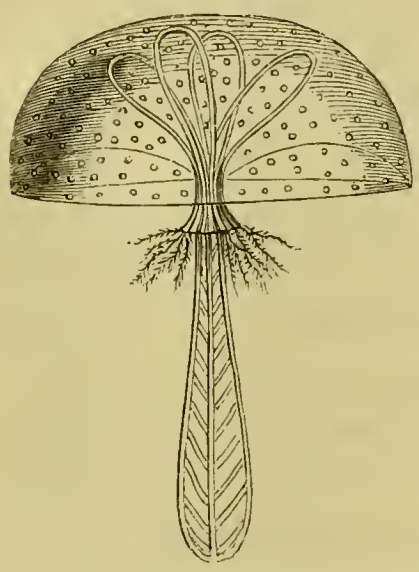
There are few of our readers who have not had an opportunity of witnessing the splendid spectacle sometimes presented by the sea when every wave is luminous and shines with phosphorescent brightness; even in our climate, during summer time, the ocean seems to glow with liquid light that streams from every ripple on its tranquil surface. Should a passing breeze sweep over the bosom of the deep, a blaze of splendour follows it that spreads for miles: the sailing ship leaves a long wake of glory, stretching far behind it: the raised oar drips with bright gems;

or should the hand take up a little of the water, it seems turned to living diamonds as the agitation calls its splendour forth. Should you inquire the cause of a phenomenon so beautiful, the sailor universally replies, it is "the saltness of the sea," and, seeming well satisfied with this mysterious explanation, appears to deem the subject settled. From age to age the inquiry goes no further,—and why? Because when first the question was discussed philosophers themselves assigned this reason, and their *dictum* still exacts unquestioned homage. Being much amused at hearing this answer invariably given, we were well pleased by accident to find the source of such a doctrine. Turning the pages of old Thomas Hobbes, one of the patriarchs of modern science, whose works upon Philosophy and Physics appeared about the year 1665, when knowledge still was young, we found the following explanation of "the cause of light in the concussion of the sea-water." "Also," says that truly learned old writer, "the sea-water shineth when it is either dashed with the strokes of oars or when a ship in its course breaks strongly through it; but more or less according as the wind blows from different points. The cause whereof may be this, that the particles of salt, though they never shine in the salt pits where they are but slowly drawn up by the sun, being here beaten up into the air in greater quantities and with more force are withal made to turn round, and consequently to shine, though weakly. I have, therefore, given a possible cause of this phenomenon."

Ingenious as this theory might be deemed in those

days, when physics and metaphysics reigned triumphant, and were constantly appealed to, to explain by subtle theories, not facts, whatever seemed abstruse in nature, widely did they err from the grand truth. Throughout the immeasurable expanse of waves that encircles all this globe, sharing the already crowded drops of water lavishly, these stars of ocean have been sown in microscopic myriads, a living milky-way. Partly from their small size, but more from their extreme transparency, they escape all observation by day-time, nor can they be seen even by the microscope, so perfectly translucent are the bodies; but as the night reveals the stars of heaven, so does the darkness bring to light these living luminaries, else invisible, contrasting, as it were, with those above, and silently repeating the great truths they tell.

Fig. 65.



> "To Him no high, no low, no great, no small;
> He fills, he bounds, connects, and equals all."

But let us dwell a little longer on the contemplation of these sparkling beauties of the sea, if but to estimate, as far as our imagination can, the extent of this department of creation. It has been calculated by navigators every way entitled to respect, that, at some seasons of the year, when the *Acalephs*

swim near the surface, and of course their phosphorescent light is most conspicuous, at least thirty or forty thousand must exist in every cubic foot of the sea-water! That through this mass of life, from day to day, from week to week, from month to month, the vessel ploughs her rapid course, nor finds the slightest diminution in their numbers! We leave the reader, then, to draw his own conclusions, and exclaim with an old writer, "Surely if the sky has stars so has the sea likewise!"*

But all are not thus diminutive that crowd the surface of the ocean; some, as the *Rhizostoma* of our own coast, attain to large dimensions, weighing many pounds; yet even these larger forms so abound in some climates, that the sea seems clogged up with their multitudes, and the labouring ship for days together has to toil along through the dense mass of life which burns by night like fire.

* The author is here forcibly reminded of a spectacle to which he once was witness in the Bay of Naples, one of the most picturesque, perhaps, that can be imagined. After having ascended to the summit of Vesuvius during the grand eruption of 1832, and remained all night upon the mountain, "in mute amazement lost," he had to return to Naples in an open boat just as the day began to break, whilst the moon, near its full, shone with unclouded splendour. Seldom is such a variety of lights so wonderfully blended as there was on that occasion. The thundering mountain with its glowing sides of lava casting gleams of ruddy fire across the waves, the gentle moonlight dancing on the sea, the faint grey dawn tinging the east, whilst through its whole extent the heaving bay streamed with phosphorescent scintillations! At intervals volcanic lightnings flashing from the pitchy cloud that overhung the mountain, mingled their wild glare and formed a scene not easily described nor soon forgot.

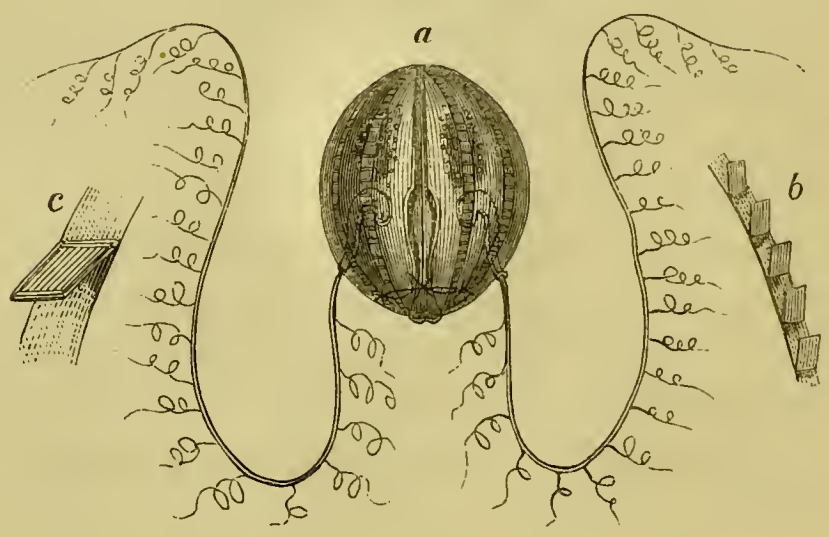
And, now having laid before the reader a somewhat detailed account of the general structure of the *Acalephæ*, and of the wonderful faculties conferred upon them, let us call in the physiologist to our aid, and ask him to explain how they are endowed with such various attributes. They perform voluntary movements, contracting the discs of their bodies and their tentacles at will, and that with sufficient energy to row themselves about through the element in which they reside. What are their locomotive agents? Muscles, the physiologist would be inclined to answer. But here are no muscles, neither does even the microscope succeed in pointing out the existence of muscular fibre in any one of them. They feel; and, consequently, as the physiologist would say, they must possess a nervous system; but yet they have no nerves; or if they have, as some authors have asserted, proofs yet are wanting to confirm the fact of their existence. In short, to use the words of Peron, in these *Acalephæ*, "we find the most important functions of life performed in bodies which offer little more to the eye than a mass of jelly. They grow frequently to a large size, so as to measure several feet in diameter, and yet we cannot always determine what are their organs of nutrition; they move with rapidity and continue their motions for a long time, and yet we cannot always satisfactorily demonstrate their muscular system. Their secretions are frequently very abundant, and yet the secreting organs remain to be discovered. They seem too weak to seize any vigorous animal, and yet fishes are sometimes their prey. Their delicate

stomachs appear to be wholly incapable of acting upon such food, and yet it is digested within a very short time. Most of them shine at night with very great brilliancy, and yet we know little or nothing of the agent which produces so remarkable an effect, or of the organs by which their phosphorescence is elaborated. And, lastly, many of them sting the hand which touches them, but how or by what means they do so still remains a mystery."

Having, therefore, failed to account for the phenomena displayed by these *Acalephs* from any known physiological data, let us appeal to chemistry. Bid the chemist, even the chemist of modern times, to approach one of these mysterious beings, and let him bring his balances with him, those balances in which he weighs the elements and apportions their almost imponderable atoms. He shall take one of the largest, weighing, perhaps, five or six pounds, and, setting it aside to let the portion of its fluid substance drain away, he finds that all the solid matter left is but a film of cellulosity, a cob-web, weighing not as many grains as did the living creature pounds. The fluid drained away let him examine, and he tells us that it is sea-water, undistinguishable from that wherein the creature swam while yet alive. What must we say to this? That the salt-water of the sea, imprisoned in a web so delicate as scarcely to be visible, is moulded into all the beauteous shapes we have examined or as yet shall see the *Acalephs* put on; and, being possessed of life, the mass thus formed becomes susceptible of being endowed with properties like those we have discussed.

But let us turn to other forms if possible more beautiful than those we have examined. At certain seasons of the year our creeks and estuaries are found to swarm with little *Acalephs* to which the names of *beroë* and *cydippe* have been given. Of one of these, *Cydippe pileus*, the shape and natural size are represented in the figure hereunto annexed (fig. 66, *a*).

Fig. 66.



When taken from its native element and placed in a glass jar for close inspection, the body of this elegant animal looks like a little globe of purest ice, and is, indeed, almost as deliquescent, for when exposed it melts away almost to nothing,—for no residue is left except a film, so delicate as to be scarcely visible. Still, while alive, few objects could excite more pleasurable emotions in the observer.

Man justly prides himself among the countless triumphs of his intellect over the stubborn elements, at his success in having found the means of struggling through the opposing surge propelled by steam-

revolving wheels, whose paddles urge his vessel on with giant force. But man in this contrivance, as in many more, is but a bungling artist when compared with Nature, when he chooses to adopt machinery which she likewise has employed.

Examine well the *beroë* and see if any paddle wheels can equal hers. Stretching from pole to pole of this translucent little orb, like lines of longitude upon a globe, and placed at equal distances are eight broad bands of more consistence than the other portions of the body. On these bands are placed thirty or forty paddles, broad flat plates, for such they seem when magnified, with which the little creature rows itself along. But here the difference lies between the art of man and Nature. Man to move his wheels must have much cumbersome machinery; the furnace, and the boiler, and the Herculean arm that makes the wheel revolve; but here all these may be dispensed with, for the paddles are themselves alive, and move themselves at will with such degree of force as may be needed, either at once or singly or in groups, working with mutual consent in any way required. Thus do they all work equally; the *beroë* shoots along meteor-like, or, if a few relax their energy, wheels round in broad gyrations, or revolves on its own axis with an ease and grace inimitable. The paddles are, in fact, gigantic *cilia*, all instinct with life, all acting independently, yet all associating with the rest. How far their power of moving is their own and not produced by foreign agency, the following observations, obligingly forwarded to me by Mr.

Patterson of Belfast, one of our most industrious naturalists, will serve to show. This gentleman remarks that on one occasion he took two *beroës* after a storm, with some of the *cilia* abraded and other parts of the body shattered and even torn. Many of the *cilia*, however, which were attached to these mutilated parts, retained all their former mobility unimpaired. The most damaged of these *beroës* was then cut with a pair of scissors into several pieces, and each part exhibited in its *cilia* the same undiminished rapidity of movement. One of these portions was again subdivided into parts so minute as to possess only one or two *cilia* on each, yet no change in the ceaseless motion of these extraordinary organs took place. Thirty-three hours after this minute subdivision, several of them were vibrating as usual, and at the expiration of forty-two hours the *cilia* belonging to one fragment showed undiminished activity.

Another curious circumstance which may, perhaps, hereafter assist in throwing additional light upon the nature of ciliary motion, is the wonderful and instantaneous effect produced by the application of fresh water to the *cilia* of a marine animal, and *vice versa*, of salt water to the *cilia* of a fresh-water species. In the case of the *beroë*, Mr. Patterson notices that, however vigorous, the moment it is plunged into fresh-water, ciliary action is at once stopped, and the creature sinks, apparently dead, to the bottom of the jar. But if instantly taken out and replaced in its proper element, the *cilia* again begin to act. This we ourselves have frequently

observed in other animals, though it is difficult to explain how movements of such vigour should be paralyzed at once by such an application. But to return. Our little *beroë* thus propelled by means of its wonderful paddles, has to feed itself; and here it may be asked on what a creature organized like this can feed? What food can be devised so feeble as to fall a prey to such an unarmed helpless animal, so delicate as not to injure the fine texture of its fragile body? Here we have another wonder. The *beroë* lives on shrimps and small crustaceans, swallows them shell and all, with all its spines and prickles and dissolves them too, appropriating their soft parts as food, and casting out again what is intractable. Its mode of catching prey like this is singular. Its stomach, or the cavity which represents that organ, passes straight through its body, opening at both poles. This passage, as the *beroë* swims along, is widely open, and the water rushes through, bringing, of course, whatever it contains into the pervious tube. But should some little shrimp or other creature fit for food be brought into its body with the stream, the little *Acaleph* becomes a living trap, and, closing on its victim, easily prevents egress.

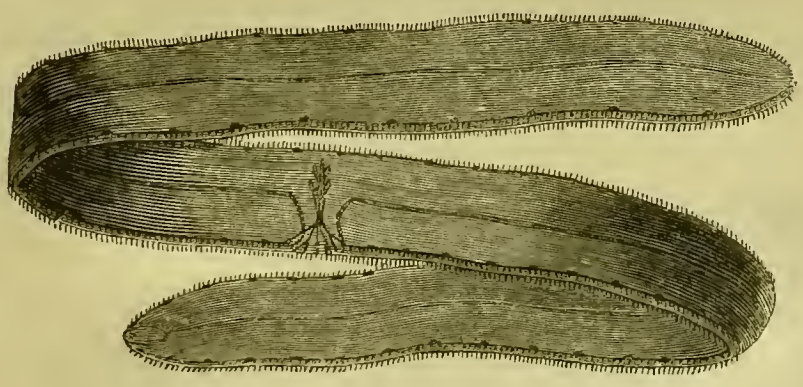
One other circumstance connected with the economy of these admirable little beings, and we must quit the tempting subject. The *beroë*, when first seized, seems but a ciliated globe, without appendages of any kind attached to its exterior. But if left undisturbed, it can display a set of tentacles or feelers of unique and most admirable construction. When folded up, these curious organs are

enclosed in the interior of the creature's body, lodged in little pouches represented in the figure, from which, when needed, there stretch out two long slender filaments, elongating themselves, as though by magic, till they reach the length of several inches. Meanwhile as growing from these primary stems a second set of filaments uncurl themselves like tendrils of even greater delicacy, till the organs, when extended to their full length, with all their filaments developed, assume the appearance shown in the preceding figure (fig. 66).

The length of these curious tentacles when completely extended, is frequently more than six times that of the longest diameter of the body of the *beroë*, and in one case Mr. Patterson observed a specimen, only half an inch in diameter, protrude them to the extent of five inches, as ascertained by actual measurement; even the secondary tendril-like filaments are not less than half an inch in length, and frequently as many as fifty of these may be counted on a single tentacle. These singularly elegant organs are, moreover, when protruded, continually assuming new aspects, so that it is scarcely possible to convey by any description an idea of the beauty and diversity of their forms. They seem endowed with exquisite sensibility, which, however, is not always equally delicate. At times, the slightest touch will cause a tentaculum to be drawn back into its tube with a sudden jerk, while at other times it is apparently unfelt. The *beroës* never seem poised or supported in the water by these elongated arms, though occasionally they are extended to the

bottom of the vessel, where they seemed to act as suckers, and formed fixed points whence the animal rose and fell at pleasure, and appeared as if moored by these delicate and novel cables. The precise function of these graceful appendages to the body of the *beroë* is, however, not precisely understood. Some writers regard them as instruments of touch, others of prehension; but this latter opinion is contested by Mr. Patterson, to whom we are indebted for the preceding observations, who states that, during all his observations, he never saw them thus employed, nor from their position can they be easily made to approach, the mouth being appended to the hinder part of the body, floating backwards as the creature swims along.

Fig. 67.



Widely differing in its external appearance from the *beroë* last described, though zoologically allied to those *Acalephæ* in many points of its economy, is the *cestum Veneris*, or *girdle of Venus*, a zone well worthy of the sea-born queen of beauty. These creatures, still more admirable in their structure than the last, are met with only in warm climates, and

even there are found by no means frequently. The *cestum*, delineated (fig. 67) is an inhabitant of the Mediterranean, where it fails not to excite the wonder of every naturalist whose good fortune gives him an opportunity of studying its habits or examining its structure.

The animal appears at first to be a long flat riband of translucent glass, but so extremely soft and tender that the slightest force breaks down or tears its substance, so that it is scarcely possible to obtain a perfect specimen, its length being sometimes six or seven feet, whilst its breadth is only three or four inches. The margins of its body are fringed round with rows of locomotive cilia, countless in number, and endowed with all the powers of those conferred upon the *beroë*. These are its oars, which, by their constant action, row it on in graceful undulations through the gently heaving waters of those tranquil seas. By day the cilia, from their rapid motion, act upon the light, dispersing it in gorgeous rainbow hues, or in the night they shine with brilliant phosphorescent splendour visible at a considerable depth, and marking, as by flame, the creature's path.

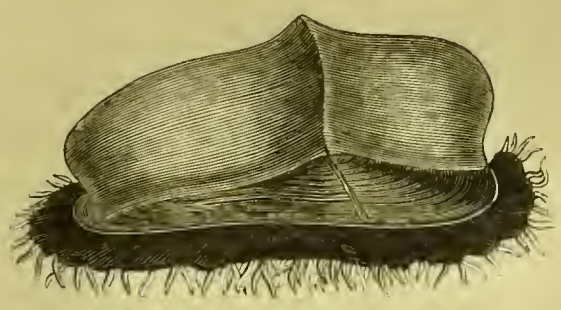
But besides acting thus as oars, the cilia have another office to perform,—that of supplying food. The creature's mouth is merely a small orifice placed on the upper margin near the middle of its body, and having neither senses to perceive nor limbs to seize materials for its sustenance, were not some extraordinary provision made for its support, the *cestum* soon would perish. To obviate this, the cilia, as they row the creature on, form currents in the water as they

pass, which, flowing towards the mouth, hurry in that direction all the little animals the water may contain, and thus feed the *cestum* without the slightest effort on its part.

The stomach soon dissolves and turns the substances thus furnished into nutriment, which then passes through long canals, seen in the figure, to the remotest parts of the long body, whilst other tubes running beneath the ciliary bands, there expose the fluids they contain to the influence of the aerated water around, and thus provide the means of respiration.

Let us now take another step, and once again see Nature change her plans, lay by the oars which late she used, to guide the *beroë* and the *cestum* through their liquid element and hoist a sail instead, prepared to catch the breeze that wafts the little bark thus furnished o'er the waves.

Fig. 68.



The *Velella scaphoidea*, (fig. 68,) is a little *Acaleph* provided thus. Its body is a flattened disc, shown in the figure, of its natural size, which floats upon the bosom of the sea, and as it swims we see depending from its under surface a great number of small suckers, (*cirri*, they are generally named,) wherewith to suck up food as it moves slowly onwards. Projecting from the upper surface is the broad flat sail seen in the portrait

of the creature given above, a soft transparent membrane, but still strong enough for the light boat that bears it.

But if a sail be given to beings such as these, whose bodies we have seen already are almost of the same density as the salt water in which they live, and at the same time so soft in their consistence, some provision must be made to float the tiny ship and keep it buoyant. A mast is likewise needful, and moreover ballast must be furnished to secure its steady course, and keep it from capsizing. All these are furnished, and by means as simple as they are efficient. Unlike the other *Acalephs*, whose body is entirely soft, these species form in the substance of their backs a shelly plate, so thin as scarcely to be visible, and yet so porous that being filled with air it is extremely light, so much so as to constitue a float by means of which the creature swims. Placed vertically on the top of this stands up another lamina of shell still thinner than the former, planted in the substance of the sail; this forms the mast, and gives sufficient strength and stiffness to enable the thin filmy sail to stand erect against the wind, which otherwise would be impossible. The ballast is obtained from other sources; small shells and stones are seized by the appendages upon the lower surface of the body, which, from their weight, may serve to trim the little vessel as it scuds along, climbing the billows as they rise and fall, or slowly sailing on the tranquil deep.

The sail in the preceding case is fixed, and constantly extended; yet even this deficiency, if such

it can be called, is sometimes remedied. In certain species fine contractile bands are interwoven with the spreading sail, wherewith to reef it if occasion needs, and thus allow the helpless little skiff to shrink from observation or escape from danger.

Yet admirably formed as is the *Velella*, still more elegant are many species found in southern climes. Witness the exquisite construction of the *Acaleph* figured by Peron, *Cuvieria carisochroma*,* whose body is a flat transparent disc tinted with roseate hues, through which are seen to ramify the food-preparing tubes. Around the disc, enclosing it like pearls set round a miniature, is placed a circle of transparent globes, all filled with air to act the part of floats, sustained by which this gem of ocean rests upon the sea, while, from its whole circumference, long wavy tentacles hang down like silken fringes.

A far more common example of an *Acaleph* furnished with a hydrostatic apparatus adapted to enable it to float buoyantly over the waves, is met with in the *Physalus*, or, as the seamen call it, the "Portuguese man-of-war." The body of the *Physalus* consists of one large pear-shaped vesicle containing air, which floats upon the water like a bladder. From its lower part depend a great variety of suckers and tentacula and wavy ribands of most diverse forms serving for different offices: some seem constructed to seize hold of prey; some formed for sucking nutriment, whilst some appear to bear the eggs.

Upon the upper surface of the bladder is affixed

* For figures of this and the succeeding genera of *Acalephæ*, the reader may consult my General Outline of the Animal Kingdom.

a purple sail of richest dye, which, spreading to the wind, the *Physalus* scuds gaily onwards, sometimes in company with a whole fleet of others, catching, as it sails, whatever substances the sea affords for food. Should danger threaten, or the creature wish to sink into the waves, the bladder shrinks and forces out the air through orifices placed at either end. Its float being emptied thus, the "little man-of-war" is hidden speedily beneath the waves until it choose again to rise up to the surface. To accomplish this, it once more fills its float and straightway mounts like a balloon until it gains the top, where, spreading out its sail, it once again careers gladly upon the sun-illumined billows.

But here we naturally inquire, how does the *Physalus*, when sunk beneath the surface, perhaps to a considerable depth, obtain the air wherewith to fill its float? Here, doubtless, is another instance of peculiar secreting power conferred for special purposes. The fish, we know, has its air-bladder, filled with air secreted by itself, and why should not the *Acaleph* in question be endowed with similar power of forming gas at once, distending thus its float at will.

The *Medusæ*, observe those distinguished naturalists Messrs. Quoy and Gaimard, are the most universally diffused of all pelagic animals; they are met with in every sea from Greenland to Cape Horn, but more especially in intertropical climates. Sometimes they may possibly combat the waves by swimming, but it is more probable that in storms they sink down to find at great depths more tranquil

water. It is only indeed during calms that their legions appear at the surface, and it is not unfrequent for the navigator to sail for days together in the middle of swarms of these animals all floating in the same direction. When carried along by a persistent current, they may traverse vast distances, and thus arrive in very different latitudes, so that the same species are occasionally found on the remotest shores, and hence it is impossible to say that a given species inhabits such and such a locality. Nevertheless, the *Acalephs* of the torrid zone differ from those of cold climates, and, like all animals that enjoy abundant light or heat, sparkle in the water, resplendent with the most gorgeous colours, while those of more frigid seas are generally sombre-looking and colourless, remaining, during the winter, sluggishly at the bottom, whence they mount up in spring to float amongst the waves.

Notwithstanding that many of the *Acalephæ* devour living prey, and that the *Physalus* more especially sucks and digests fishes destroyed by the paralyzing agency of its tentacula, the writers above referred to seem to think it probable, that some species are nourished by other means, inasmuch as in them no digestive apparatus has as yet been discovered. A species, for example, to which the name of *Dyanea* has been applied, seems to furnish an incontrovertible proof of this fact, seeing that its body presents no opening whatever into which solid food could be supposed to pass, and yet its texture seems in all respects similar to that of the carnivorous species.

By far the best observations upon the internal structure of the *Acalephæ* are those for which science is indebted to M. Milne Edwards, a naturalist whose patient and accurate researches in connection with the history of many tribes of marine animals entitle his opinions to have very great weight, and we shall now, therefore, proceed to lay before the reader some of the most important circumstances detailed by this eminent zoologist.

Professor Grant, in his account of the *Beroë pileus*, of which a portrait has been given in a preceding page (fig. 66), has described a nervous system consisting of a ring of ganglia united to each other by double nervous filaments surrounding the *posterior* extremity of the body, but the observations of the distinguished Professor of University College subsequent explorators have been quite unable to confirm, although hundreds of specimens have been diligently examined for this purpose.

Professor Ehrenberg, as we have already noticed, thought he had discovered nervous filaments in *Medusæ*, and M. Milne Edwards seems to favour the opinion, that in many of the most highly organized *Acalephs* a nervous system begins to be apparent.

In *Lusueuria*, for example, a *Medusa* that, from its transparency seems to be remarkably calculated for observations of this kind, Milne Edwards detected a spherical nucleus situated in the axis of its body, which was rendered conspicuous by its red colour, and had a granulated appearance precisely resembling the brilliant spots that surround the disc of the *Medusa*, (fig. 64,) and which Ehrenberg re-

gards as being optical instruments. "In the construction of *Leuseuria*," says Milne Edwards,* "its conformation is so characteristic that I think it difficult to refuse to recognize it as being really the centre of a nervous apparatus. In fact, immediately beneath the eye-like spot, there is a small pear-shaped body, in every way resembling a ganglion, which is more opaque in texture than the surrounding parts, and gives origin to a great number of filaments. The disposition of the whole apparatus exhibits the greatest analogy with that of the nervous system of some of the tunicated mollusca, only the filaments that I regard as being nerves are not all placed upon the same plane, but form four bundles, which descend obliquely towards the inferior and external margin of the principal lobes of the creature's body. Some very delicate filaments appear to stop near the base of the accessory lobes, but the greater portion may be traced to the neighbourhood of a row of filiform appendages situated near the edge of each of the principal lobes, and appear to give off branches as they approach these organs."

Lastly there exists beneath each of the rows of cilia a little longitudinal filament that appears likewise to be nervous in its nature, and which gives off on each side a multitude of branches, which arise in very regular bundles beneath each of the transverse ridges to which the ciliary fringes are attached, and towards the middle of each of the spaces separating those ridges. It even appears as if there was a minute gangliform enlargement at the origin of the

* Annales des Sciences, Nat. N. S. tom. xvi. p. 206.

nervous branches that correspond to the ciliary ridges, but this is doubtful. At the superior extremity of the body the vertical filaments are continued beyond the ciliary fringes, and unite together in pairs as they approach the central ganglion that is placed beneath the eye-like spot, to which organ they were very nearly traceable, although Milne Edwards could not positively satisfy himself that they communicated with it. From the above observations, the French physiologist concludes that in *Lesueuria* and some *beroës*, a distinct nervous system exists, but very different from that described by Dr. Grant in *Cydippe* (*beroë*) *pileus*, and offering great and interesting analogies with the nervous apparatus found in the humblest tribes of the mollusca, with which, indeed, the highest forms of *Medusæ* become progressively allied in several points of their economy.

Equally interesting are some of the observations of the same naturalist relative to the condition of the vessels through which the nutritious fluids are distributed to all parts of the body of some of the *Medusæ*. All these vessels seem to be filled with a fluid that is in continual movement, hurrying along with it multitudes of round colourless globules. This nutritious fluid, or blood as we must call it, circulates with great rapidity, although there is no moving power present at all analogous to what is met with in the higher animals, seeing that these creatures possess neither a heart nor contractile vessels. The place of these organs is, however, supplied by innumerable vibratile cilia placed in the

vessels themselves, which, by a movement so constant and rapid as to render it difficult to distinguish them, urged on the contained fluid in perpetual currents. Surely even the little *beroë* is itself a microcosm well calculated to extort admiration from the most obtuse.

The enormous fertility of the *Acalephæ* may be inferred from what has been already stated concerning the numbers in which they swarm at certain seasons of the year in the waters of every sea; nevertheless, such have been the difficulties attendant upon any consecutive study of their economy, owing to the impossibility of keeping them alive for any length of time in a state of confinement that even yet but little is known relative to this portion of their history, and naturalists have occasionally fallen into strange mistakes relative to this portion of their economy. In the umbrella-shaped species some authors have supposed that the eggs were formed in pouches that open into the stomach, whence they are ejected when mature, as in the case of the *Actinia;* others have pointed out glandular sacs, sometimes of a red colour, situated around the margin of the gelatinous disc in which it was thought ova might be secreted; an opinion that seemed rendered probable by the fact, that these coloured spots are not always to be detected, a circumstance which might depend upon their being in a collapsed and empty state; but these organs are pronounced by Ehrenberg to be eyes. In the globular species such as *beroë,* Professor Grant noticed two cavities placed on the sides of the stomach, as represented in the

figure which is copied from his drawing of that animal; these being filled with red globular bodies, he took to be bags of eggs, but from subsequent observations made by Professor Forbes and Mr. Patterson, the red substances in question turn out to be the eyes and indigestible parts of shrimps and other little crustaceans upon which these creatures live lodged in pouches connected with the digestive canal: such is the confusion that ensues when specific names are applied to animal structures, the nature of which is obscure or imperfectly determined.

In *Æquorea*, according to the comparatively recent observations of Milne Edwards, a multitude of membranous lamellæ are visible upon the lower surface of the body, diverging on all sides from the central mouth like rays, or like the spokes of a wheel. Of these radiating folds no fewer than seventy-four were counted in a single individual, all of which were filled with innumerable germs of future progeny, which must at certain seasons be poured forth by countless thousands into the surrounding sea, and thus the source of the prodigious swarms of these *Acalephs* that people the great deep is easily explained.

Unfortunately our knowledge of this portion of the history of the *Acalephæ* is at present very imperfect; but quite sufficient has been already established to stimulate the curiosity of future observers, and to induce them, whenever opportunity occurs, to prosecute, with increased diligence, researches which have already revealed to the naturalist some of the most extraordinary phenomena witnessed in

the animal creation. The young *Acalephs* have, in fact, been proved by M. Sars and other observers to undergo a strange series of metamorphoses both as relates to their form and structure, by which they are apparently converted at different periods of their existence into individuals of most opposite characters. They exist at first as real eggs, which are developed in the body of the parent animal, and resemble in every particular the eggs from which the more elevated races of beings are invariably produced.

These eggs being hatched, however, do not give birth to creatures at all resembling the original *Medusa*, but to animals that might easily be mistaken for infusorial animalcules, having their bodies everywhere covered over with vibratile cilia, by means of which they swim about with the utmost vivacity until the first period of their growth is accomplished. In the next state of their existence they seem to be absolutely converted into polyps. Settling down upon some foreign body they become firmly attached to it by means of a sucker, or adhesive pedicle, whilst tentacles that are at this time developed around their mouth enable them to catch prey precisely in the same manner as the hydra described in a former chapter.

Whilst in this polyp condition, moreover, they are capable of multiplying themselves exactly as polyps do, by buds that sprout from different parts of their body, or by offsets that issue from the base of hydriform animals, and ultimately by spontaneous division, the original mass, in the course of an hour

or so dividing itself into a crowd of animals which soon disperse and move about vivaciously as separate beings, assuming gradually the form of swimming and free *Acalephæ*. If, therefore, the observations of M. Sars be correct, and there seems no reason to doubt their accuracy, we arrive perforce at this strange and startling conclusion, that it is not the animal originally formed in the egg that grows to be the perfect *Acaleph*, but the young ones that result from it by spontaneous division while existing under quite another form; so that it is not the young *Medusa* itself, but the young of the young *Medusa*, that becomes converted into the perfect animal; it is not the original progeny, but the race that undergoes a progressive metamorphosis until a being, similar to the original one, is again developed,—a circumstance, however, which, extraordinary as it may seem, is not without a parallel in creation as we shall have to notice hereafter, when we come to describe the *Salpæ* and other kindred inhabitants of the sea.

CHAPTER IX.

NEMATONEURA.

CŒLELMINTHA.

We are now about to introduce the reader to another, and more exalted, series of living beings; and must, therefore, pause for an instant to review the principal features whereby the animals, whose history has been discussed in the preceding chapters, are distinguished from those upon the study of which we are now entering; and shall at once perceive that the creatures we are about to contemplate are constructed on a totally different plan, are far more complex in their general organization, and obviously endowed with higher attributes.

The Acrita, notwithstanding the diversity of their forms and habits, have been found invariably to present certain common characters indicative of the humble rank assigned to them in the economy of Nature. They are, for example, all destitute of nerves, of muscles, and, as far as we know, of the organs appropriated to the exercise of the higher senses. Moreover, that their digestive organs consist of mere excavations, or canals, that permeate

the solid texture of their bodies, and at once prepare and convey throughout the system materials for nourishment. We now, however, arrive at a series of beings more elaborately organized, and presenting, as the anatomist would say, a higher type of structure; they possess, for example, powers of locomotion far more vigorous than those bestowed upon any of the acrite races; they are furnished with distinct and separate muscles, rendering them capable of precise and active movements. Nervous threads are distinguishable for the first time; which, like electrical telegraphs, associate the various motions of the body, and so permit increased activity and strength to be conferred on creatures thus endowed.

The Entozoa, for instance—those parasitic worms described in a former chapter, and which, as we have seen, perhaps with some disquietude, are frequently enclosed in other animals, shut up in narrow cells, or so confined as to render all communication with the external world impossible—are, simple as their structure is, adapted to the prison they inhabit; to them it would have been absurd to grant exalted faculties, organs of sense, or even any capability of locomotion. Yet, creatures may be found, nearly allied to these in form and habits, which, being placed in other circumstances, where they have room to move about at will, and range from place to place in search of aliment, must be constructed in accordance with the liberty allowed them, and possess both nerves and muscles; in fact, they differ so widely from the Entozoa we have described, that

naturalists have been necessitated to group them together, as forming a distinct class, to which they have given the name of CŒLELMINTHA.*

These worms, as they are generally named, for such they appear, at least in outward form, are met with in innumerable animals occupying every possible situation, and occasionally existing in great numbers. Their bodies are long and cylindrical, and being flexible in all directions, although unprovided with limbs, they can work their way from one part to another of the locality which they inhabit with considerable facility. Senses they have none, except the generally-diffused sense of touch, but, nevertheless, they are sufficiently perfect for the duties assigned to them, and, not infrequently, become dangerous inmates to the unfortunate beings in which they take up their abode.

The *Filaria Medinensis*, or Guinea-worm—so great a pest in warmer climates—may be adduced as one example of the race. This creature lives within the legs and feet of human beings who have those parts exposed to their attacks, where, lodged beneath the skin, it sometimes grows to many feet in length; until the pain it causes makes its presence troublesome. When this occurs the natives draw it out with extreme caution lest, by breaking it, its eggs should become scattered and thus prove the cause of future suffering.

The *Ascarides* and *Trichocephali* abound in the digestive organs. The *Ophiostoma* is met with in

* Entozoa having hollow bodies wherein the stomach and other viscera are found loosely suspended in an abdominal cavity.

the air-bladders of fish; others reside within the kidneys, or are found in countless numbers in the blood-vessels, the air-tubes of the lungs, or even in the general cavities and hollow sinuses of every portion of the body. The list might be extended;* but we must refrain from noticing again the ENTOZOA, having said enough, in a preceding chapter, for our present purpose, which is to reveal how densely it has pleased the ALL-WISE CREATOR to place animals wherever life could be maintained.

Let us pass on.

* The student who would wish to acquire a knowledge of those anatomical details which would be unsuitable to the nature and scope of the present work, is referred to our "*General Outline of the Animal Kingdom.*"

CHAPTER X.

EPIZOA.

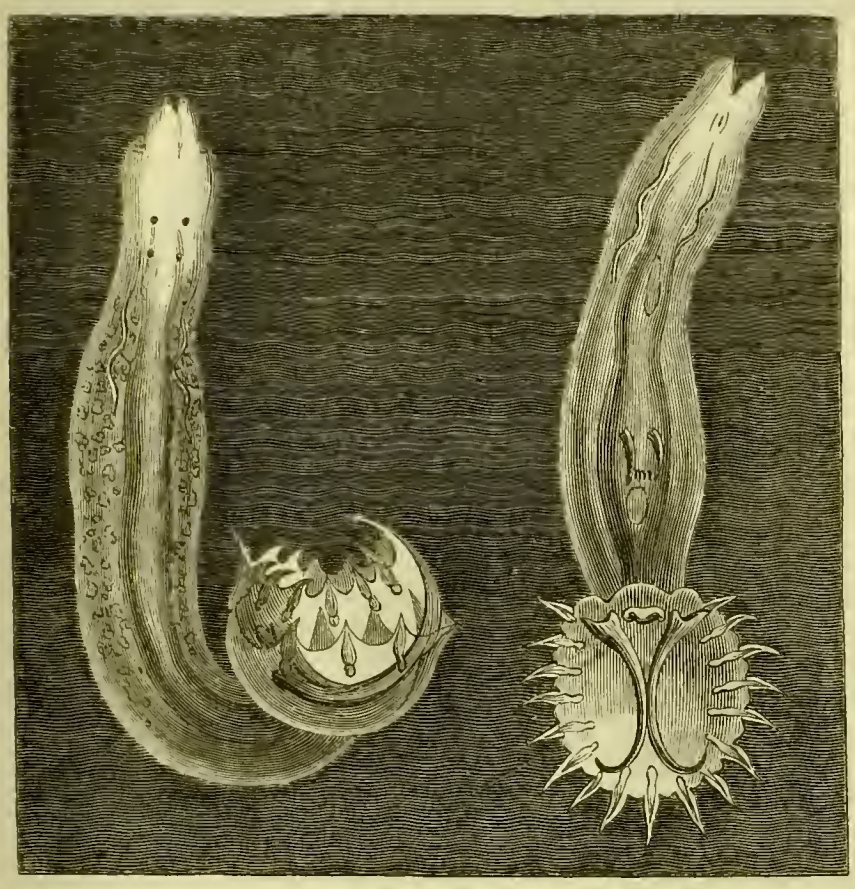
We have already shown with what profuseness animal existences have been distributed wherever they could be sustained; how jealously no spot is left unpeopled. But there are yet localities, whence food can be procured, left unexamined; though we have seen the waters swarming with innumerable forms of acrite beings, and even living bodies filled with hungry parasites. The surfaces of fishes may be made to yield support to humbler creatures. If the rocks are clothed with living beings, why should not the skins of such aquatic animals as yield sufficient room be likewise occupied, for food can there be found? The integument, the eyes, the mouths of fishes, and the gills of many marine tribes, afford a fitting residence, if creatures can be formed able to stick tenaciously thereon, and suck the blood and other nutrient juices, that situations like these furnish in rich abundance. Let us not be astonished, then, to find another numerous race of parasitic beings specially appointed to reside on the exterior of other animals, and able thence to obtain the nourishment they need.

The Epizoa* that compose the next great class we have to notice, form indeed a strange and grotesque group. They are all obviously destined to attach themselves to some part of the surface of the body of another creature, and, whilst there located, to suck the blood on which they live; whilst the surrounding medium furnishes them with the means of respiration. We will, therefore, examine a few of the most remarkable, as examples of their form and structure.

The *Gyrodactylus* (fig. 69. 1), here represented very highly magnified, is found attached to the gills of certain fishes, more especially of the Bream (*Cypr. brama*). This little parasite, the length of which is, fortunately, not more than the one hundredth part of an inch, would, as we shall immediately perceive, were it of larger dimensions, form rather an uncomfortable and dangerous companion; and, moreover, one not easily shaken off from the locality where it chooses to fix itself. At one extremity of the creature's body, as will be seen in the figure, Nature has provided a grappling instrument of no inefficient construction; but, on the contrary, of a contrivance truly formidable to behold, even when its natural dimensions are but very slightly exaggerated. A circular and fleshy disc is armed around its whole circumference with pointed incurved fangs, as sharp as tigers' claws, and in the centre we perceive still larger tenter-hooks, adapted to be plunged deeply into the flesh on which the creature fastens,

* Epizoa, so called because they live *upon* other animals; ἐπὶ *upon*, Ζῶον *an animal*.

Fig. 69.



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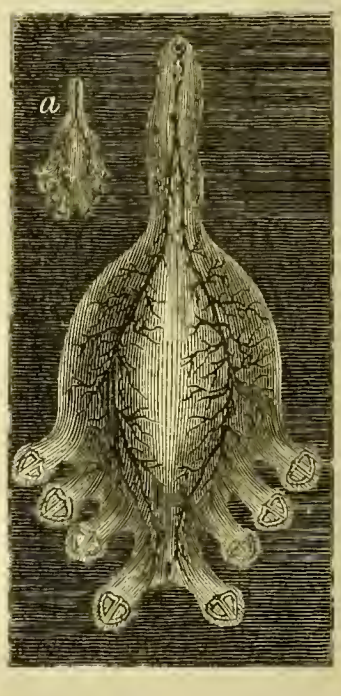
and takes hold so firmly, that to detach it would seem impossible. Upon the body, other hooks are seen disposed, as though to fix each part securely in its place; while with its mouth it sucks the nutrient juices that it lives upon, and finds a plenteous banquet at the expense of its poor victim.

In other cases, though apparently the parts attacked are similar, and we should think an apparatus like that just described might be enough to give secure attachment, Nature has been pleased to change her plan entirely, as it were to show mechanical resources without end! The whiting, (*Gadus merlangus*,) for example, carries on its gills blood-sucking

parasites, to which the name of *Octobothrium* has been applied, the natural size and shape of which the appended woodcut shows (fig. 70, *a*). This Epizoon has eight instruments fixed round the hinder margin of its body, each of which presents a fleshy plate, furnished with sucking-flaps of strange appearance, so arranged as to take firmly hold upon the fish's gills; while, anchored thus securely, by its mouth, placed at the termination of a slender neck, it readily imbibes the animal fluids met with copiously in its vicinity, which, being already fully animalized, and fitted for diffusion through the body of the Epizoon, are brought at once, by ramifying pipes, to every part, and thus the creature lives almost without exertion.

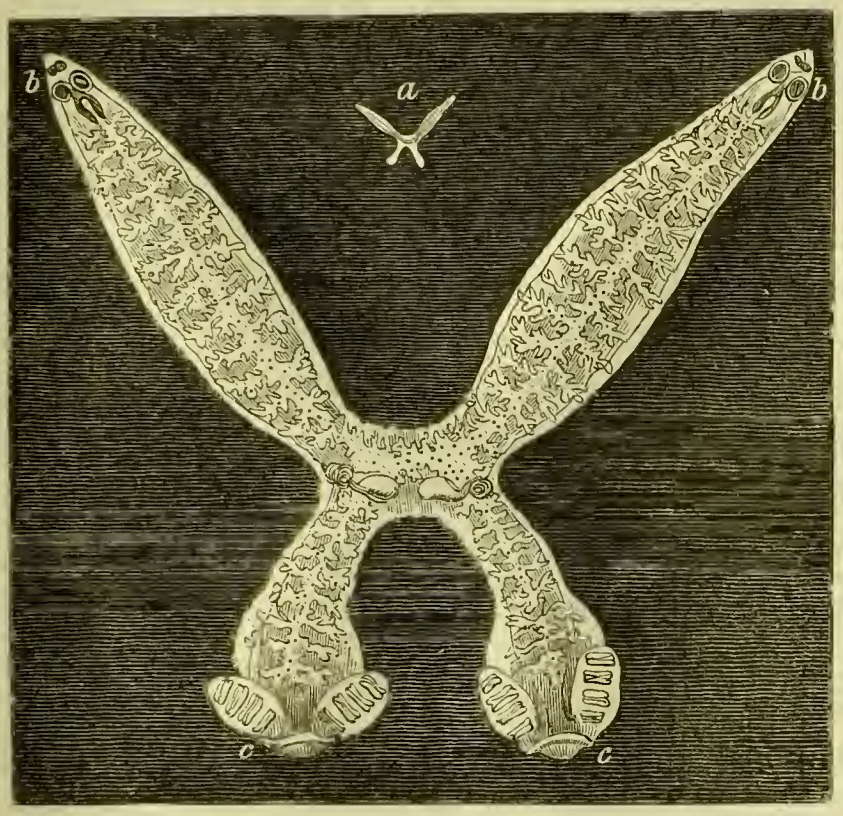
Fig. 70.



Yet, perhaps, one of the strangest of these parasites is the *Diplozoon paradoxicum*, delineated in figure 71, *a*, wherein its general appearance and natural size are at once made intelligible; whilst on the same block it is represented upon a magnified scale, and the singular details of its structure thus rendered easily perceptible. The *Diplozoon paradoxicum*, or paradoxical two-bodied animal, (for such is the name not inappropriately bestowed upon this creature,) is met with upon the gills of the Bream, (*Cyprinus brama*,) where it fixes itself by the assistance of a holding apparatus of very

remarkable structure. Its body obviously consists of two halves, precisely resembling each other;

Fig. 71.



or rather it is made up of two animals, each complete in itself, but united by a kind of Siamese-twinship with the associated portion. Each half possesses a complete and accurately-constructed mouth, adapted both to perforate the skin whereon it fastens, and to abstract by suction blood, or other fluids; and likewise, at the other end, is placed a system of broad suckers (fig. 71, *c*, *c*) that will take firm hold of the smooth surface upon which the *Diplozoon* chooses to take up its residence.

The oral apparatus is provided with divers small and lancet-shaped teeth, of sharpness adequate to pierce the thin covering of the fish's gills to a sufficient depth, and, moreover, is so constructed as to perform the office of a complete syringe, in the manner following:—the mouth itself is a cylindrical cavity, in which there projects a fleshy tongue, destined, apparently, to represent the piston of the exhausting pump, and to cause by its contraction a sucking force whereby the blood is extracted, in the same manner as by the cupping-glass of the medical practitioner, and doubtless fills itself with equal facility. Commencing from the cavities of the two mouths, wide tubes extend themselves into the interior of the creature, penetrating, by their ramifications, every part of the corresponding side of the body, and communicating freely with those of the opposite side by a wide passage that traverses the isthmus-like process, uniting the two portions of this remarkably-constructed worm.

The alimentary tubes themselves are filled with blood extracted from the gills of the fish, which, from its red colour, renders the course of the nutrient canals beautifully conspicuous.

But here the reader might be tempted to observe that, although in the animal we are now contemplating we have two mouths, we have only one stomach, and, consequently, the *Diplozoon* could hardly be considered as being composed of two conjoined creatures merely from the circumstance of its having a plurality of mouths, seeing

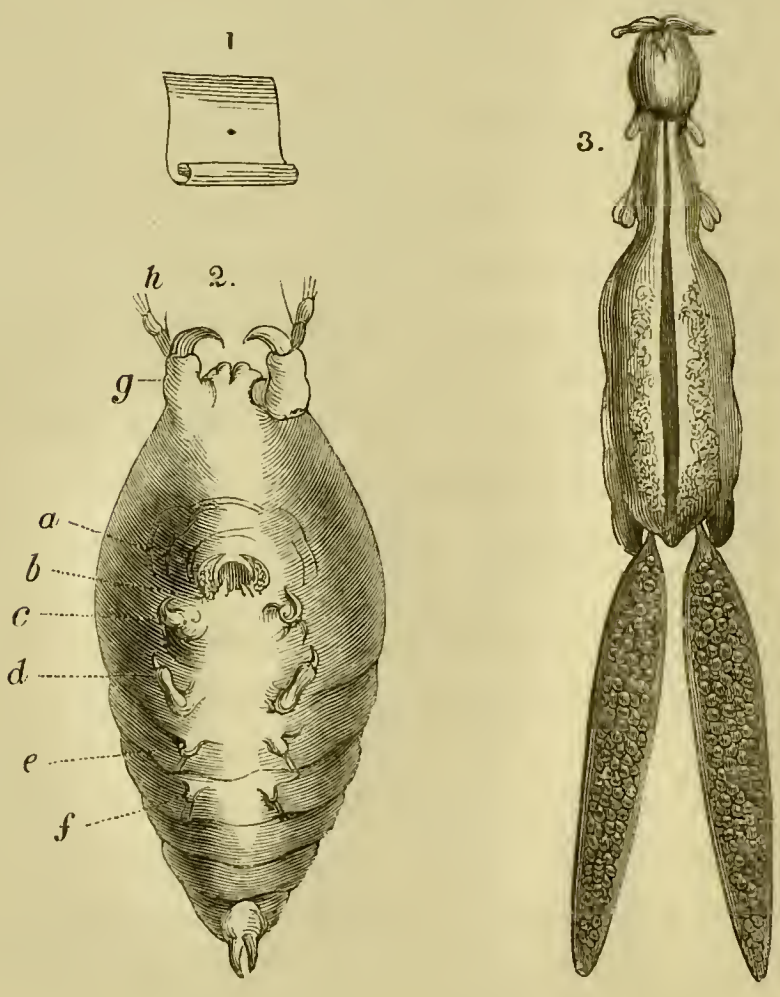
that, in several cases, as for example, in *Cœnurus*, and many *Zoophytes*, one body is nourished by many oral organs; and the remark would be perfectly just, only that, in the case before us, each moiety of the *Diplozoon* contains a distinct system of reproductive organs, and all the parts required for the formation of complete and fertile eggs, quite independently of the other — an evidence of individuality not to be controverted.

Passing on from these humbler forms of *Epizoa*, which, from their configuration and structure, are obviously nearly related to the *Sterelmintha*, or parenchymatous *Entozoa*, we are gradually introduced, through a long and interesting series of equally parasitic beings, to creatures that progressively approximate the articulated division of the animal creation, and assume rudimentary legs, and other external appendages, that seem to be the first sproutings of those jointed limbs which are only met with in a fully-developed form among Crustaceans and Insects. We shall, therefore, next select a few examples calculated to exhibit these gradations of organization.

The *Chondrocanthus cornutus* (fig. 72) first offers itself to our notice,—a parasite found upon the gills of the Sole (*Solea vulgaris*) and the Plaice (*platessa*), fishes which, doubtless, might feel themselves not a little incommoded by the close attachment of such blood-suckers, did not the small size of the *Epizoa* limit, in an important degree, their power of annoyance; the dimensions of these creatures are, indeed, so minute, as to render their presence not very easy

of detection. The *Chondrocanthus* is, in fact, not larger than the dot exhibited in the centre of the scroll represented in the figure (fig. 72, 1), but when magnified, as shown in the same figure (2), its powers of doing injury appear really formidable. Upon the

Fig. 72.



surface of its body indications of a segmented division of the external integument are already conspicuous, and upon the segments so formed limbs become apparent, of different shapes, and adapted to various offices, which are important additions to its economy.

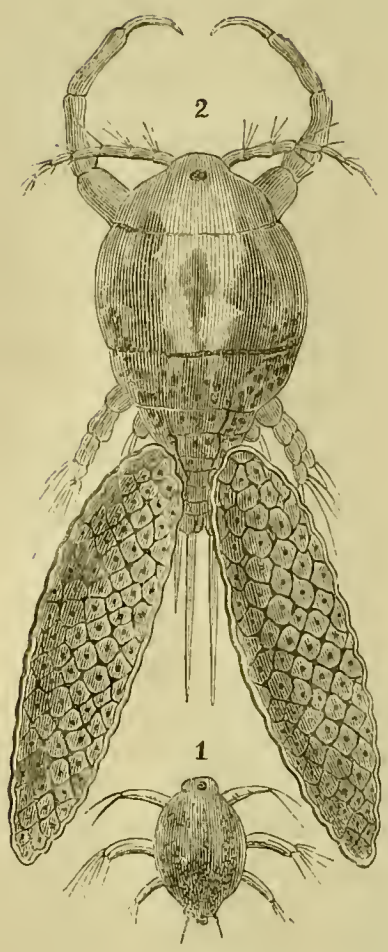
Most of these are armed with strong hooked claws (*c, d, e, f*), and one pair (*g*), of similar construction, but more robust and powerful, situated near the anterior part of the body, is particularly efficient. By means of these hooked limbs, which are plunged securely into the substance of the fish's gills, a firm anchorage is maintained; whilst others (*a, b*), placed on each side of the mouth, perform the office of jaws, and enable the parasite to derive aliment from the vascular surface to which it is attached.

In the female (fig. 3), the segmental structure of the body is by no means so remarkable as in the other sex; the limbs are far more rudimentary: so that it is almost entirely by the jaws in the neighbourhood of the mouth that the creature retains its hold and procures nourishment.

Attached to the hinder end of the body of the female, are two long, transparent bags, wherein the eggs are lodged until mature; but their construction will be best understood by examining them in other genera of more elaborate organization which next claim our notice.

The *Ergasilus* (fig. 73, 2) is manifestly still more nearly allied to animals constructed after the manner of shrimps and insects. This creature, like the last, takes up its quarters upon the gills of fishes, and that so numerously, that six hundred of them have been taken from the gills of a single fish (*pagrus*). The segments, or rings, of its body are now plainly visible; the hooked claws attached to the anterior part, whereby the creature fixes itself to the fringes

Fig. 73.



of the fish's gills, are jointed and moveable; whilst those appended to the hinder segments are fringed with hairs, and seem capable, to a certain extent, of performing the duties of little fins, so as to enable it to change its position, and probably to swim about to a little distance from its usual resting-place. Instruments of sense now therefore become requisite, and we have little difficulty in recognizing their presence: — jointed antennæ, which are, doubtless, tactile organs, are appended to each side of the head; and at the base of these a single eye, in the shape of a red spot, occupying the centre of the head, is distinctly apparent; but here the eye presents a very manifest difference of structure to those red spots, called eyes, which we have noticed as existing in acrite beings, and in all respects resembles those of the humbler crustaceans with which the *Ergasilus* is most closely related.

But we must not fail to notice another most important provision, the necessity for which will at once appear evident, although in its nature it is sufficiently wonderful. During the adult condition

of these parasites they are, from the very circumstances under which they are placed, stationary, and but little endowed with the means of locomotion; it becomes a problem, therefore, how they ever make their way to the situations they are destined to inhabit, or become diffused through the ocean in such abundance as to cause their presence to be so general! To allow of this we find another beautiful example of a compensating contrivance, scarcely less admirable than that observed in the gemmules of the sponge! It has been distinctly ascertained that, when first hatched from the egg, many genera differ most remarkably, both in form and habits, from the parents whence they were produced, being at that period entirely formed for natation, and furnished with swimming organs quite different in appearance from the prehensile claws subsequently bestowed upon them. In *Ergasilus*, for example, this change in the character of the legs is very satisfactorily established, the young, on leaving the egg (fig. 73, 1), being provided only with natatory feet, densely fringed with hairs, so as to give them the expansion of fins, and render them powerful agents in effecting locomotion; and it is only after successive moults and changes of skin that the prehensile organs of the full-grown animal become completed, when it is enabled to fix itself in situations adapted to supply those animal fluids with which the mature *Epizoon* is destined to be nourished.

In *Actheres*,—another remarkable genus of these parasites, and the last which need be mentioned in this place,—the changes the animal undergoes during

its growth are even yet more remarkable ; emulating indeed those which occur in the insect tribes hereafter to be discussed.

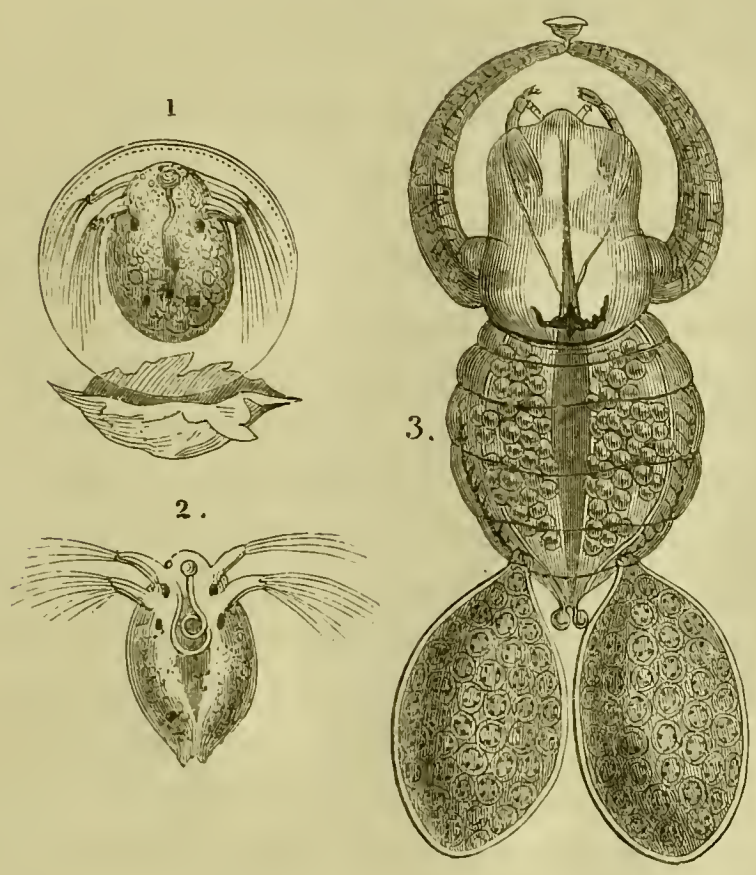
The covering of the egg (fig. 74, 1) is sufficiently transparent to allow the contained young to be distinctly visible; and it is seen, thus circumstanced, to have but four fringed natatory feet, which it can move like paddles even before it bursts the shell.

At birth it has the form depicted in the second figure, and can swim about with ease from place to place in search of a fit residence; this it soon finds in a locality which some of us might think but little fitted to afford security or pleasure. Entering the mouth of some poor Perch (*Perca fluviatilis*), it there casts anchor, and securely holds itself imbedded in the slime that coats the palate or the tongue. To enable it so to do, its limbs are changed; the legs, before made only for swimming, are replaced by others of unique construction : one strong, stout arm (fig. 74, 3) mounts up on either side, above the head, and there it meets its fellow: to the point of junction where these limbs unite, is fixed a little basin-like appendage studded within with recurved hooks ; this instrument it fixes firmly to the fish's gums, and swings in safety, in despite of all the currents that continually flow through its strange abode. Its mouth is also armed with jaws and hooks to give it firm attachment; while within its body a simple straight canal, dilated slightly in the centre, forms a stomach sufficient to digest the already animalized food the creature lives upon. On either side the stomach are perceptible two organs filled

with eggs, the germs of future progeny, which, as they are formed, pass down into two delicate bags appended near the tail, where they are carried till mature.

Such is, in brief, the history of the EPIZOA;

Fig. 74.



creatures formed to suck their nutriment from other animals and to live upon their surface, as the ENTOZOA did within; their numbers equally contributing to prove the immensity of animated Nature, and the wondrous artifice whereby each spot, where life could be sustained, is peopled with appropriate occupants.

CHAPTER XI.

BRYOZOA.*

Once more we must retrace our steps, in order to lay before the reader another striking example of the wide differences that may exist between animals, apparently, as far as outward form is concerned, most nearly related.

Throughout the extensive class of polyps we encountered an immense series of creatures which, however diversified in appearance and habits, presented the same general type of structure, and in the details of their internal organization most closely resembled each other. The beings which now court our attention would, doubtless, at first sight, be looked upon as true polyps by any superficial naturalist; and, even by the most celebrated writers on Zoology, they remained, up to a very recent period, undistinguished from those zoophytes, although, as we shall soon perceive, the differences that separate them are very wide and conspicuous. Possibly, indeed, the identity of the localities where the two classes are met with, and, moreover, the circumstance of many of the Bryozoa being absolutely parasitically attached to polyps, properly so called, long favoured the idea that they were animals of the

* Βρύον, sea-moss; Ζῶον, animal.

same description; but that such a supposition was erroneous we must now proceed to demonstrate.

The sea-side naturalist well knows how abundant upon some shores are those sea-weeds, as the ignorant term them, better designated by the names of *Flustræ*, *Escharæ*, &c. Of these, on our own coasts, the *Flustra foliacea* is found in great profusion: and, indeed, cart-loads of this so-called weed may be picked up on every beach, where it lies, but too generally neglected and unknown, as though it were a shapeless, unformed substance, quite beneath the attention of the passer-by.

When, however, a small portion of this Flustra is placed beneath the microscope, the young naturalist finds out, perhaps to his astonishment, that every part of the leaf-like fabric is made up of closely aggregated cups, or cells, arranged with the utmost regularity and order; and, as his eye peruses microscopically the whole of the extensive surface presented by the flat, membranous-looking and palmate substance, he soon discovers that it is made up, from one end to the other, of countless cells of similar configuration, which, although from their smallness almost imperceptible by unassisted vision, are individually constructed with the most exquisite art and symmetry!

But, if thus admirable are the beauties appertaining to the dead skeleton of a Bryozoon,—for such is the *Flustra* in this condition,—what would be the delight of the observer of nature did he see it tenanted by its appointed occupants, and find each cell to be the residence of a distinct and perfect

animal?—a creature, polyp-like in shape, but far more wonderful than any polyp we have yet described!

But when, while scrutinizing this same *Flustra*, he perceived a mossy-looking substance spread upon its surface, coating it with down, and found delicate filaments of moss alive—composed of cells containing living beings of kindred form to those which occupy the chambers of the *Flustra*, equally perfect in their structure, or, perhaps, more highly organized than they—what would he say to such a spectacle?

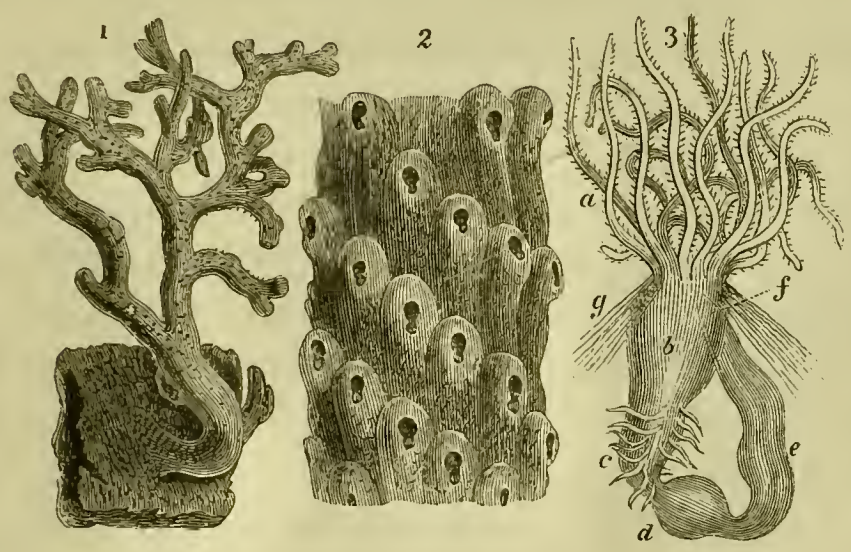
Various are the forms of these admirably-constructed animals; every species having some peculiarity by which it is distinguished. Some have membranous, or horny, cells of exquisite transparency; so thin, indeed, that with a microscope the whole enclosed creature may be seen, and all its movements accurately discerned, even to the working of the living threads that constitute its muscles! Others are lodged in cups of stony hardness, and, in consequence, are far less easily observed;—but let us take a few examples; such as best elucidate their structure and their general history.

The *Escharæ* resemble Flustræ in most points, except in this: their skeleton is dense and stony, containing in its substance a great quantity of earthy matter, similar to that found in the polyparies of many polyps. The stem entire is seen in the annexed figure (fig. 75, 1), branching out like a small stunted tree, and formed of chalky substance. Every branch when magnified, as shown in the same figure (2), we perceive to be made up of cells as regularly arranged as those of any

honey-comb; and, in some species, every little cell is closed, as by a door, to keep from harm the inmate when retired within the precincts of its domicile!

The animal itself, drawn out from this abode, is also represented (3), and is found to be constructed like a polyp, with long tentacles (*a*) around its mouth wherewith to catch its prey. A stomach, too, is seen (*b*), to which succeeds a long digestive tube (*c, d, e, f*), which in the polyps, as we may remember, did not exist at all: muscles also (*f, g*) are now

Fig. 75.



apparent, of very perfect structure, provided to retract the body of the animal—another striking feature in which these creatures differ from all the acrite families. These circumstances are perceived even in the *Eschars* when the chalky crust that covers them has been removed by acids; but in other genera, where the transparent shell permits the observer to inspect all that occurs within, even in the living animal, much more is made apparent;

we now, therefore, turn to one of these for more minute examination.

The living Bryozoon (fig. 76), depicted in the act of catching prey, is furnished with a shell so exquisitely delicate, that it would seem to have been framed on purpose to allow the physiologist to see Nature's machinery at work without a veil, revealing to the microscope each movement, which, in other animals, is for the most part scrupulously hid. The tentacles themselves must first attract our notice. In polyps these were simple, flexible filaments, or petal-like expansions, only fit to seize such animals as chance caused to impinge upon them, which then were slowly dragged into the bag-like stomach there to be dissolved. But the sluggish and languid efforts of the arms of a true polyp, although fully adequate to procure sufficient nutriment for a creature so apathetic and inactive, would by no means be competent to satisfy the cravings of the more active and, consequently, more hungry Bryozoon. Nutriment must now be supplied in never-failing abundance, and the conversion of the food swallowed into nutriment must be effected with a rapidity proportioned to the increased energies bestowed upon animals so highly organized as those we are now about to examine. The whole nutritive apparatus is, therefore, changed; and we find the Bryozoa at once distinguishable from polyps, properly so called, both by the apparatus given to them whereby to catch their prey, and likewise by the organs employed in preparing and digesting it. In the Bryozoon represented in the next figure,

the tentacula around the mouth are seen expanded, as when in the act of fishing for a meal; but, instead of being flexible, as those of a polyp, they are each of them kept stiff and motionless, forming a kind of funnel, or cone, composed of fifteen or sixteen delicate stems, the apex of the cone surrounding the oral orifice. It is, however, evident that, with tentacles such as these, prey could hardly be captured had not Nature adopted some further artifice; and, accordingly, we soon perceive additional means employed, the perfection of which may well strike the beholder with admiration.

Every one of the bristle-like tentacula is, when examined with a microscope during life, at once seen to be covered with multitudinous cilia, all in furious vibration, which, acting after the manner of so many thousand paddles, urge on the water around them in strong and rapid currents; the course of which is indicated in the figure by the direction of imaginary arrows.

Fig. 76.

Constantly these streams of water pour along, some rushing along the inner aspect of each tentacle towards the mouth, and hurrying thither whatever food is brought within their influence. Escape out of this living whirlpool seems impossible; and every tiny being that approaches its dread margin perishes.

Charybdis, with its fabled terrors, could not bear comparison with the fierce vortex thus produced. Soon as an animalcule comes within a given distance, it is whirled along directly to the mouth, the centre of the gulph, where, if admissible as food, it enters and is swallowed: or, if rejected, it is dashed away by other currents running different ways and hurried to a distance. Neither does our admiration cease after the food has passed the opening of the mouth, for in the throat itself innumerable cilia are busily in motion, turning round and round the swallowed victim, urging it along until it reach the stomach, where its struggles end.

Some species of Bryozoa surpass even these in beauty and in exquisite design, and that so widely, that the forms described above seem clumsy structures when compared with others more elaborately organized. We will select but one of the more perfect kinds and briefly give its history. A genus named *Bowerbankia* is met with most abundantly upon our coasts; of which, when magnified, a representation is given in fig. 77.

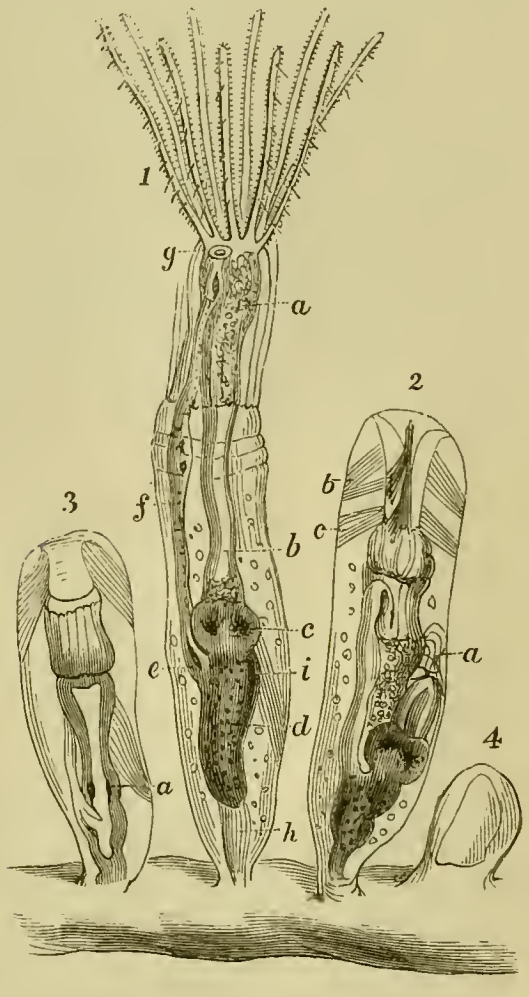
We see at once that in its general details it agrees with those described already; but the attentive eye will soon perceive new features visible in its economy, refinements as it were on what appeared already perfect. To see these creatures well, and thoroughly examine them, requires but little trouble. When by the sea-side, pick up the wrack and sea-weed, freshly floated to the shore, in which are found varieties of *Flustræ* and of *Corallines*. On these

the naked eye perceives patches of mossy substance growing in little tufts, each patch being formed of countless cells, adherent to a flexuous stem, and every cell when magnified is found to be the residence of one of these minute yet admirable creatures. When placed in shallow troughs made of thin glass, and filled with fresh sea-water, they are easily submitted to the microscope, and may be kept alive for days, affording all the time fresh scenes of wonder. The cell itself first claims attention. In the genus last described, the opening of the cell was plain and undefended; but we here perceive provision made for guarding the abode of *Bowerbankia* by a mechanism at once so simple and so beautiful, that he who examines it most closely will admire it most.

Around the orifice of each transparent cell, Nature has placed a circlet of long, horny filaments, which, when the creature is concealed within, close down and touch each other by their points, defying all intrusion from without, but giving ready passage to the tentacles whenever the Bryozoon chooses to protrude its head in search of prey. The whole arrangement is, indeed, precisely similar to what we find in a wire mouse-trap, where the cone of wires admits the mouse, but closes to refuse all exit when the intruder is entrapped. Contrast, for instance, the condition of these delicate organs, as represented at fig, 77, 1, *a*, with the same parts in their retracted state, as shown in the same figure (2), and then the mechanism of this ingenious door, or rather valve, as it might here be called, will be at

once intelligible. In the second figure, in fact, the *setæ* around the mouth of the shell are not only closely approximated so as to close the opening,

Fig. 77.



but are themselves withdrawn out of the reach of injury and packed within the cell itself.

Even in the oral tentacles we find improvement in the mechanism. Besides the countless cilia that produce the food-supplying currents, we perceive stiff bristles fixed upon each arm, which are not moveable, but seem to serve as hedges to keep off rude contact from the cilia themselves, and to pre-

vent the near approach of such rude particles as else might clog the ciliary movements.

Within the body, too, additional parts are found employed for special uses. The passage for the food (1. *a*, *b*) does not here terminate directly in the stomach (*d*), but there is interposed a grinding apparatus (*c*), a kind of gizzard, paved inside with horny teeth, ready to smash and bruise whatever passes through, and fit it for digestion. Muscles, too, are now distinctly visible—bundles of living ropes (1. *h*, *i*; 2. *a*, *b*, *c*) arranged with exquisite art to act upon each moving portion of the body and, by their contraction, wield the tentacles and spines, and all the viscera contained within. All these are plainly seen through the transparent shell; all busily employed in different offices, revealing as it were the springs of life and action to the wondering eyes of the beholder.

Yet, notwithstanding this elaborate structure, we must not forget the near affinities by which the Bryozoa are allied to polyps, and the plant-like form which still proclaims them zoophytes. Their mode of growth and propagation is, in fact, most similar to what we have already witnessed in the humbler tribes, and will, in many points, remind us of the vegetable kingdom. They multiply, indeed, by several different processes: first, by cuttings, as in plants; a portion of the stem removed with all its cells and their included animals still grows and lives quite independent of the rest. Another method is by buds, which sprout out from the common stem. These seem at first mere empty

vesicles (fig. 77, 4), without a trace of any future being lodged within; but as they grow the polyp-like inhabitant appears, and all its different parts become progressively developed (fig. 77, 3). When mature, the cell becomes complete, its mouth expands, the Bryozoon soon protrudes its tentacles in search of food, and all the countless cilia set to work to bring unwary victims to the mouth.

In those flattened genera, the *Flustræ*, and the *Eschars*, where the cells are closely crowded, side by side, to form a broad expansion (fig. 75), the growth is different. The central cells are those produced the first; around these others continually accumulate, like sprouts proceeding from the first; from these again others are formed, and thus they spread from centre to circumference until the fabric is complete. The youngest race is, therefore, placed around the margin, while the central cells are not unfrequently found empty, their original occupants having all perished ere their progeny have fully perfected the elaborate edifice of which themselves had been the founders.

But still another mode of propagation is required, and that for obvious reasons. It is true the plant-like growth by which accumulating cells, each filled with living animals, spread from a common origin, and thus are multiplied to thousands, might suffice if numbers only were required to be spread over a given locality; but how provide for their diffusion through the seas? The parent Bryozoa are all fixed immoveably; or if they float about from place to place, the sport of chance, it is because the angry

waves have torn them from the rock by violence and cast them loose to be washed up upon the beach there soon to perish. To meet this difficulty arrangements have been made, whereby the parents may send forth the germs of future progeny endowed with locomotion, capable of swimming freely where they choose, until a fit asylum tempts them to locate themselves, and lead henceforth a sedentary life. At certain seasons, *gemmules* are produced covered with countless cilia,—living oars, like those of SPONGES, and of many POLYPS; these, thus rendered locomotive, journey far away, shooting on like little animalcules through the sea, and so disseminate their kind through all the regions they are called upon to occupy.

CHAPTER XII.

ROTIFERA, OR WHEEL ANIMALCULES.

Let us now leave the sea, and turn again to our fresh-water pools. The ocean we have found to be replete with living beings, and though, as yet, we have but contemplated forms of life the humblest that are known, we justly feel lost in astonishment, and scarcely can tell which to admire the most, the vastness of the scenes we have gone through, or the transcendent skill and limitless beneficence conspicuous through the whole! We recognize the Power

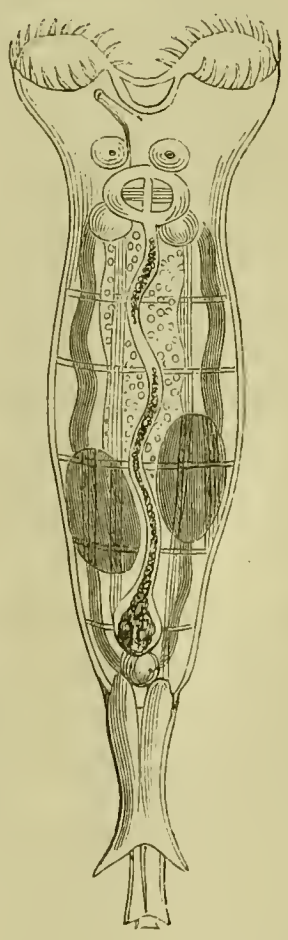
> "to us invisible, yet dimly seen
> In these His lowest works,"

and reverently pursue our course inquiring.

Our stagnant waters, we already know, swarm with innumerable tribes of Infusorial Animalcules; every drop is densely peopled, and the countless hosts have divers forms and habits, such as have been described in a preceding chapter. Returning to this spectacle, we take from any pool overgrown with duckweed a few drops, and placing them beneath our microscope carefully inspect the little world exhibited within them. The crowds of

POLYGASTRICA are recognized at once as they go gliding past, or sporting about in giddy dance; but ever and anon there comes, rushing among their swarms, like a fierce tiger midst a flock of sheep, some monster of a different kind, having, on what appears to be its head, great wheels that spin continually round, and, like the paddles of a steam-boat, row about these dread leviathans,—for such they seem, compared with the small fry around them. The animals in question have been named ROTIFERA, or wheel-bearers; in their size they much exceed the humbler *Infusoria*, over which, indeed, they tyrannize. Their length may be roughly computed at about one fiftieth to one hundredth of an inch; terrific giants when contrasted with their tiny victims, although themselves scarcely perceptible by unassisted vision!

Fig. 78.



Their shapes are various. We select a few, as samples of the rest, copied with care from Ehrenberg's elaborate figures, which will serve to show at once their outward form and general economy.

The body of a *Rotifer* (fig. 78), is cased in a thin shell of exquisite transparency, through which the

parts within are clearly visible, and every movement may be seen as accurately as in a *Bryozoon*. At the narrow end, or tail, is placed a pair of forceps, moved by little muscles, by the aid of which it seizes hold of foreign bodies when at rest, and thus can fix itself as by an anchor. The opposite extremity supports the wheels, or locomotive agents, which the animal protrudes at pleasure, and can make them spin or stop when it thinks proper; but we must pause awhile and notice these organs more particularly. Our forefathers, who saw with their imperfect instruments the rotatory movement, were, as we may well suppose, perplexed to comprehend its nature or its cause, and not a little puzzled to explain how wheels could be affixed to a living animal, and kept revolving as upon an axle. Subsequent observers have, with better means, been able to resolve this mystery, and show the whole to be an optical illusion, as relates to the supposed wheels, although both the appearance of the apparatus when seen at work under the microscope, and likewise the effects produced by its action, might well lead the earlier microscopists into error concerning its real nature.

When the organs are in full activity, so rapid is the motion produced, that it is next to impossible to make out its real nature, even with the most patient and experienced observation; but when the *Rotifer* is growing languid, and the movements are relaxed in speed, the cause of the appearance is conspicuous. On each side of the mouth is placed a circle of vibrating cilia, all in rapid motion, and,

as we have already seen them in some *Infusoria*, arranged in waves, or delicate festoons, the highest part of every wave being formed by cilia standing quite erect, while at each extreme point they are laid flat, the intervening ones exhibiting all intermediate grades of flexure; but, almost ere the observer can mark this disposition, the central cilia have bent themselves, and lie procumbent, forming now the margin of a wave, and those before laid down stand up as in its centre: thus the eye being led quite round the circle, believes it sees a wheel, while in reality each cilium but bends upon its base.

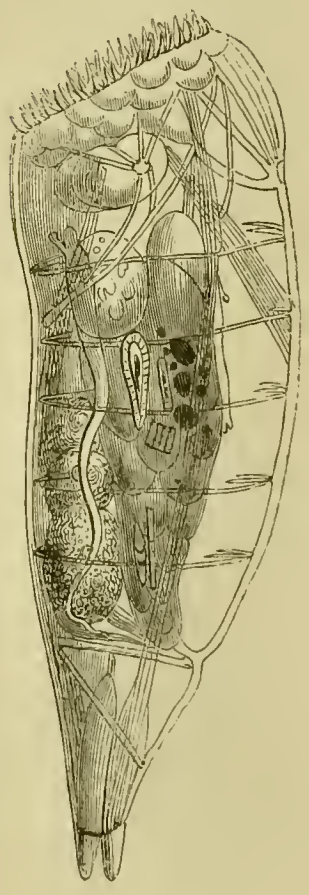
In the *Rotifer*, and many other genera, the wheel is double, as depicted in the last figure; but in some it forms a single circle (fig. 79), or seems divided into several segments (fig. 81); still the office of the organ is the same, answering a two-fold purpose. First it gives the means of locomotion, for it forms a set of paddles far more perfect than the rude propelling oars employed by human industry. Man with his paddle-wheels must have his furnaces, his boilers, and his clumsy enginery; but Nature's paddles are themselves alive, can move or stop at will, act singly or co-operate with all the rest, and thus impel the bark and steer it too.

Another use of these apparently revolving wheels, is to procure supplies of food in the same way as we have seen among the *Bryozoa*, forming whirlpools in the water that suck in whatever luckless animalcules come too near. But this involves another piece of mechanism. The *Rotifer* not being fixed, as in the former case, by any stem, but loose

and free, would be continually dragged on from place to place whenever all its cilia were put in motion, was not an anchor given; and this we find in the prehensile forceps at its tail, already noticed; seizing hold, by means of this, of any floating weed, it keeps its place, and feeds itself at leisure by the wonderful machinery with which it is provided.

The efficiency of the whole apparatus in procuring a plentiful supply of nutriment is seen in the annexed figure (fig. 79), where we observe the stomach, easily discernible through the transparent covering, filled with animalcules thus obtained, the forms of which are still distinctly recognizable.

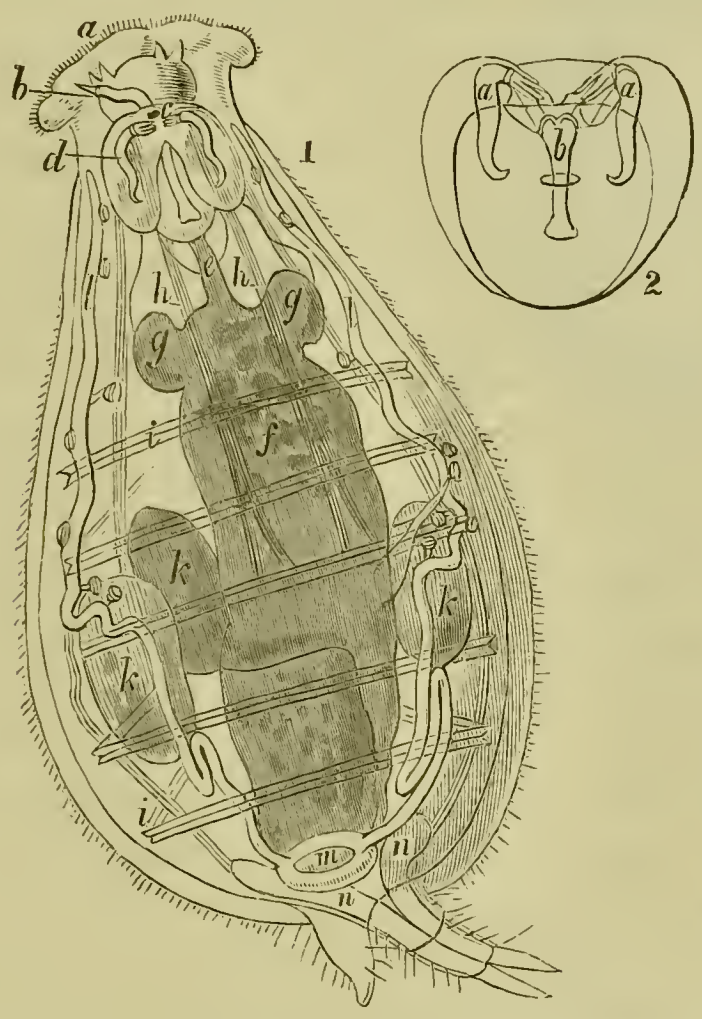
Fig. 79.



But we must now inquire a little further as to the internal structure of the animals we are discussing, for we soon perceive that, so translucent are the walls of their diaphanous bodies, that the organs placed within are easily discernible, and may be seen at work as perfectly as in the *Bryozoa* last described. These let us next examine, and at the same time compare the organization of a *Rotifer* with the more humble *Polygastrica* described in a preceding chapter.

Arrived within the mouth, the food brought by the rushing currents is at once conveyed into a sort of gizzard (fig. 80. 1, *d*), formed on most peculiar principles, and provided with a set of crushing instruments, adapted to prepare and bruise such substances

Fig. 80.



as may require this treatment ere they are submitted to the action of the stomach. This cavity, with the machinery enclosed, is represented on a larger scale in the same figure (fig. 80, 2). When thus enlarged, we see it has within a kind of horny anvil (*b*), on which two hammers (*a a*), moved by muscles des-

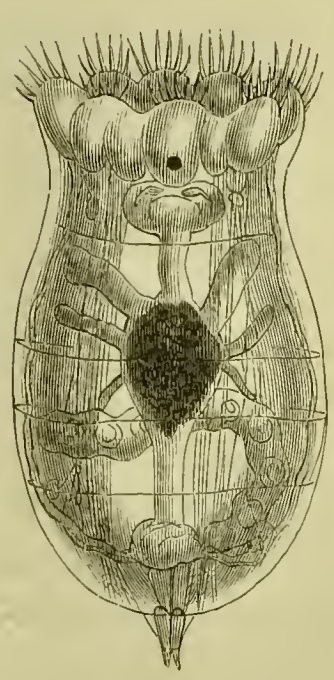
tined for the purpose work. Each of these hammers is armed with finger-like appendages, which tear and crush what is submitted to their action, and perform a kind of mastication, after which, the matter so prepared is carried through a narrow passage (*e*) into the proper stomach (*f*), wherein digestion is accomplished. Small pouches (fig. 80, 1, *g g*), in this case two in number, and, in other genera, of larger size and still more numerous, to which Ehrenberg, without the slightest reason, has thought proper to give the name of *pancreas*, (fig. 81,) communicate with this stomachal receptacle.

Upon the neck a little pipe or spur (*Calcar*) is seen, through which, apparently, water obtains admission to fill up the cavity of the body, and thus serves, perhaps, for respiration. The presence of this fluid likewise serves to explain the mode in which the, so called, wheels may be retracted or protruded as occasion needs. Long muscles (fig. 80, 1, *h h*, seen likewise in the other figures, but without letters of reference), draw them back into the shell when not in action. Other transverse bands (fig. 80, 1, *i i*) passing around the interior of the shell, compress the water there contained, and thus in turn force out the rotatory organs when required for use.

The eggs (fig. 80, *k k k*), are found in delicate bags of exquisite transparency, in which they may be seen as they are slowly formed. These pass, when ripe, into a chamber (*m*) where terminate two long and tortuous tubes (*l l*), supposed to furnish some secretion needed to complete the eggs prior to their expulsion.

The eggs, when perfected, are covered with a little shell, and may be kept and watched from hour to hour beneath the microscope, with still increasing wonder to the observer. Slowly appear the outlines of the future animal, and, as these grow more perfect, all its parts become distinctly visible, until, before the egg is hatched, the wheels are seen in rapid undulation, even within the shell, as practising their movements to prepare for an enlarged sphere of action when set free from their imprisonment!

Fig. 81.



The reader now will see how widely different, both in their outward form and general organization, are these *Rotifera* from all the *Polygastric* animalcules on which they are appointed to subsist. Nerves they possess, undoubtedly, vessels, perhaps, wherein their fluids circulate; and in some genera red spots are seen, to which the name of eyes have been applied. At all events we find them now exhibit a very elevated type of structure, when compared with animals of which we yet have spoken.

Still one circumstance connected with their history must not be left unnoticed. The Rotifers inhabit shallow pools, and not unfrequently are met with even in little puddles, or in leaden pipes that carry off rain-water from the roofs of houses,—localities,

as must at once be evident, subject continually to be left dry during a time of drought, and, when rain comes again, filled up with water. Here, then, we have a difficulty not easily to be explained on ordinary principles. How are such places, after being dried up, again replenished with fit inhabitants of such high structure as the creatures we are now discussing? Among the *Polygastric Infusoria*, indeed, we find examples, not a few, of their appearance, as it were spontaneously, in waters where, before, no trace of them existed, and, although by no means easy always to explain the mode of their diffusion, still we can conceive the germs of such invisible beings to float about, wafted upon the atmosphere, and thus arrive in situations favourable to their development, where they grow and multiply prodigiously by various kinds of propagation. But in these *Rotifera* we scarcely can fancy any such means of transport possible; we see their eggs constructed as in higher animals, nay, more, can watch their growth while still within the egg, but see no means whereby they are conveyed into the new-filled pool that seems the produce of the recent shower. Without a miracle, indeed, their quick appearance after rain, where, previously, no trace of them was visible, seems hardly explicable in any way, unless, indeed, we choose to admit that they are formed expressly, at the time, to fill the situations where we find them. But our surprise at seeing them thus suddenly, where we should least expect their presence, is much lessened when we learn an unexpected feature in their history, discovered first

by Spallanzani, whose researches on this subject have been verified by many later naturalists. This eminent observer found, to his astonishment, that some of these *Rotifera*, even when dried to dust, were not deprived of life, but, even after a considerable time, could be restored to full activity by the simple application of moisture, a circumstance which, although seemingly miraculous, is by no means without parallel, both in the animal and vegetable kingdoms.

CHAPTER XIII.

ECHINODERMATA.

The young Zoologist is too apt to consider the animal creation as consisting of a regularly progressive series of gradually improving forms of existence; race after race leading us gently on to neighbouring ones of similar construction, but exhibiting a higher organism, and thus we are tempted to speak familiarly of the "vast chain of being" as composed of links, each placed above the other like the steps of a long ladder, so that we may mount, and mount continuously, from the most humble animalcule up to Man who stands supreme! But, we shall soon perceive, when we attempt, as is our present purpose, to pursue our course from class to class, and from the lower animals mount up to others, higher in the scale of life, we cannot hold on a straightforward track; but every now and then vast chasms seem to interrupt our progress, and, before we can advance, we must retrace our steps to start again from the same point we left some distance back, ere we can step across the gulph that bars our passage onward. We find that living creatures have been formed in groups, or circles, as the phrase is now, which join with other

circles at some points of their circumference, by all of which they lead almost insensibly to races of a very different nature.

In this predicament we stand at present. Did we pass straight on, from the ROTIFERA to animals with which those little beings are most intimately related, we should leave unnoticed many important tribes of interesting creatures, which seem so widely different from anything we yet have noticed, or shall find hereafter, that the cursory observer might suppose they stood alone and unconcatenated with any other forms of life.

The *Starfishes*,—for instance, the *Sea-eggs*, *Sea-urchins*, and such creatures known by sight to every sea-side visitor, form an extensive class, to which the name ECHINODERMATA has been applied—a word which simply means, that animals belonging to it are, for the most part, characterized by having rough and spiny skins, which emulate, sometimes, the bristles of a hedgehog in their length and sharpness. But how are these to be allied with any animals we hitherto have met with? If we look at only the most typical, or characteristic, genera, they seem so far removed, and so peculiar in every circumstance connected with their history, that they would appear to stand apart; but, when we view the series as a whole, we see at once analogies before not noticed, which conduct us on from form to form without impediment or break, allying them, on one hand, with the polyps; and, at length, by slow gradations, introducing us to a new section of the Animal Creation.

But to commence our survey of the strange and truly wonderful class which now invites our notice, let us take one of the humblest of the Echinoderms depicted in the appended figure (fig. 82, *a*). It

Fig. 82.

needs not much examination to convince us, that a being such as this, if not a veritable polyp, is, at least, closely allied to Zoophytes of that description. There is a central stem on which are fixed, like branches, what appear to be true polyps from their form; for, at the end of every branch, we find a central body that contains the stomach, and around the mouth diverging tentacles disposed like rays, wherewith to seize such food as may approach

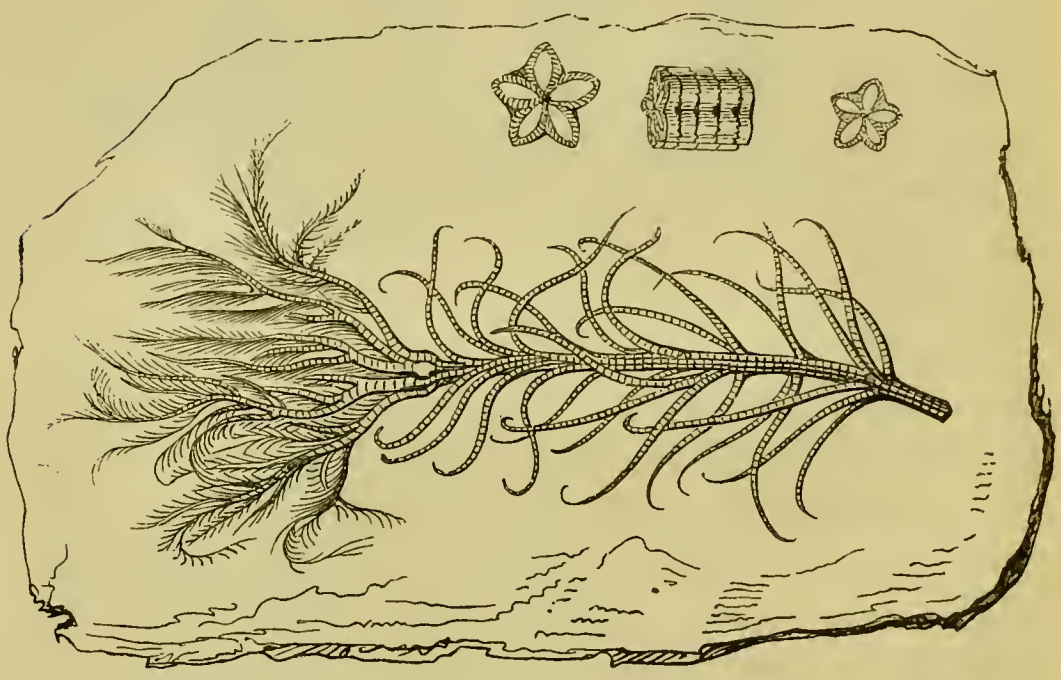
within their reach. But this is not a polyp, but an ENCRINITE *(Phytocrinus Europæus)*, the lowest of the Star-fishes, although, most obviously, related to a polyp in its form. But let us see wherein the difference lies. The polyp, as we have shewn, is soft throughout, and, if some races form external skeletons of Madrepore, while others construct tubes or cells, wherein to dwell securely, the animals themselves are all minute and mostly fixed to one locality, because they are too feeble to remove themselves from place to place. Here, without quitting yet the polyp type of structure, Nature has designed another race of animals destined to discharge important duties in her general scheme.

The first thing to be done is to give strength and firmness to the fabric of their bodies, and we see that this is easily effected. The living flesh deposits earthy matter *in its substance* (not, as heretofore, external to its body): the stem is filled with jointed pieces, held together by the soft parts, and thus a skeleton is formed which bends at will in any given direction. The body is enclosed in a calcareous box, though covered still with the investing crust of living flesh. The arms around the mouth are, likewise, filled with joints, and from their sides project subsidiary appendages of like construction. Thus constituted, then, the movements of the Encrinite become more energetic and precise; in fact, divide it from its stem and it could crawl about the bottom of the sea, using its tentacles as legs. We shall see immediately that this is the next step; but first must spare a little time to contemplate

the Encrinites a little more minutely, for they well deserve attention.

Any one acquainted with the districts that abound with limestone, must have noticed that huge blocks are met with that appear to be made up exclusively of animal remains; and in some parts seem entirely

Fig. 83.



to consist of lozenge-looking fragments, named by the unlearned "St. Cuthbert's beads," or, sometimes, these are met with undisturbed, which then, from their resemblance to the stem and flower of certain plants, are generally called "lily-stones." We give a drawing of a piece of lime-stone, such as we are now alluding to (fig. 83), and recognise, at once, the fragments of large Encrinites in every part. The broken stem, the stony body, and branched tentacles, are all conspicuous, and we want no greater proof

that lime-stone, such as this, contains the fossilized remains of animals allied to the *Phytocrinus*, above delineated (fig. 83). But when we find strata, immensely thick, reared up in mountain chains, and almost all composed of fossils, such as these, we have convincing proof that, at some previous period, the seas that then overflowed our globe must have produced innumerable tribes of Encrinitic beings, the skeletons of which accumulating for ages became imbedded in the limestone rocks as these were slowly formed.

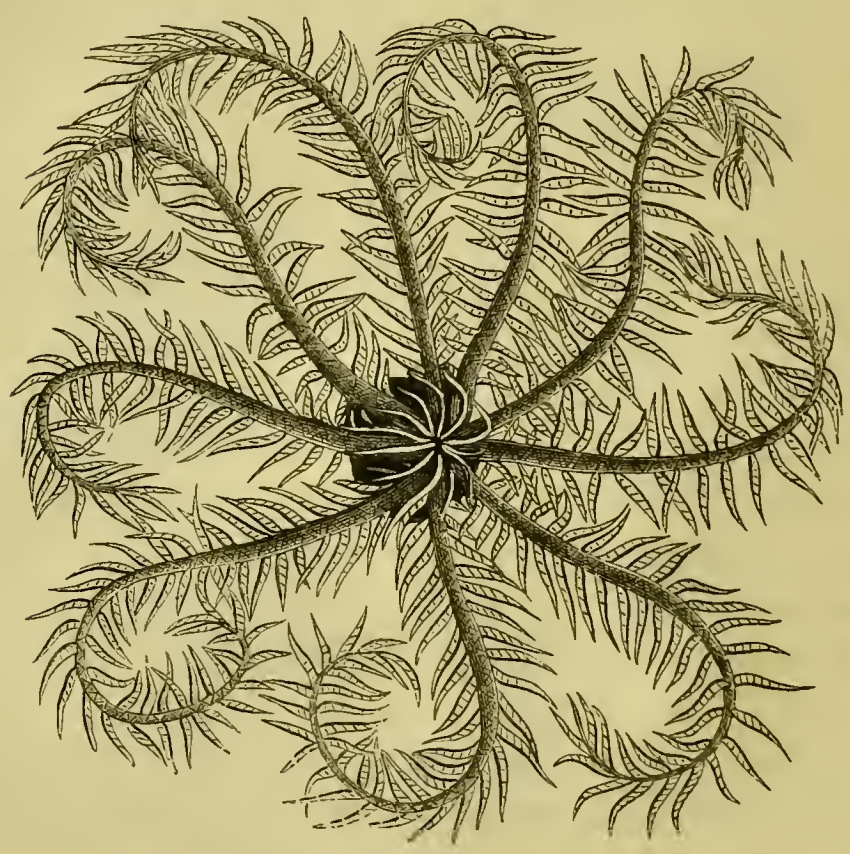
But yet, in modern seas, the Encrinites occur most rarely, and are now but little known in their fresh state. The only European form discovered yet, is the *Phytocrinus*, described in a preceding page; and this is so minute, the real dimensions of the specimen being scarcely three quarters of an inch in length (fig. 82, *b*), that it seems scarcely comparable to the gigantic growths of former times. One of larger size, obtained from tropical seas, exists in the Hunterian Museum, and two or three are found in continental cabinets; these are all the recent representatives, at present known, of animals that must have swarmed in countless myriads at the time when their innumerable skeletons must literally have paved the bottom of the then existing seas.

We thus have seen a polyp, as *Phytocrinus* appears to be, both in its shape and habits, begin to assume the complex structure of the Echinoderm, and prepared to be set free from its fixed stem to rove about at will in search of prey. Advance but one step

more, and we perceive the separation actually accomplished—the polyp body and the rays detached and set at liberty to crawl or swim as pleasure or necessity may direct its movements.

The British Feather-star (*Comatula*) (fig. 84) is evidently an animal so circumstanced. The body

Fig. 84.



that contains the stomach and digestive organs occupies the centre of its flower-like arms, enclosed in a dense calcareous box, surmounted with small tentacles that seem to act the part of feelers. Five rays, each bifurcated, spread around, formed of innumerable joints, all fringed with secondary branches

like the plumes of feathers. Every arm is covered with a thin contractile membrane that directs its movements, and, moreover, spreads on either side into broad processes that coat the supplementary branches. Thus endowed with locomotive organs, the *Comatula* can creep about at pleasure, using its long arms as feet, or twining them around the branches of sea-weeds, or corals, while it climbs in search of prey; or, does it please to swim, the lateral processes appended to each ray assume the character of fins, and, by their movements, row this graceful *Zoophyte* from rock to rock, when it would change its pasture.

The passage, then, from polyps to the star-fishes, is thus most gradually accomplished by the intervening forms we have described; but, from the recent evidence procured by naturalists, it would seem, the affinities between these classes are even yet more closely demonstrable. It is, indeed, suspected, and with every probability, that the *Phytócrinus*, the modern representative of extinct Encrinites, is but the young of the *Comatula*, which latter, till a certain age, is fixed upon a stem, but, when arrived at fit dimensions, and endowed with strength sufficient to enable it to live an independent life, becomes detached, and takes upon itself the form and habits of the free star-fishes. However this may be, the reader cannot fail to see how nearly they approximate each other.

But, even in animals like these, thus highly raised in the great scale of being, we perceive lingering

relations with the vegetable world. Their mode of increase puts us much in mind of what the botanist observes among some plants, especially the ferns.

The lateral leaves, or frondes, if we may call them so, appended to the sides of all the rays of the *Comatula*, are filled with dark brown spots, which seem to be receptacles for eggs, all which, at certain periods, are found filled with germs of countless offspring. Professor Forbes* has counted these *ovaria*, and found their numbers to exceed 57,000 in a single specimen! The reader hence may judge how numerous the progeny!

Proceeding onwards towards other forms of these Echinoderms, we soon shall find the changes they progressively present reducible to one grand principle, which we will here explain. The radiated structure has, throughout the lower animals, as yet been dominant; hence Cuvier was induced to apply to all the races we have hitherto discussed, the general name of RADIATA, though, as has been shown, the term is very far from being applicable to many classes grouped beneath that title. Here, however, we perceive the radiate type in full perfection in the humbler genera of Star-fishes, and, constantly as we advance towards the higher members of the extensive class of which they form a part, it slowly grows more and more inconspicuous, till we are led, at last, to worm-like creatures, introducing us, at length, to insect forms of life towards which we are approaching. The reader, perhaps, may smile at this assertion, and perceive as little chance of

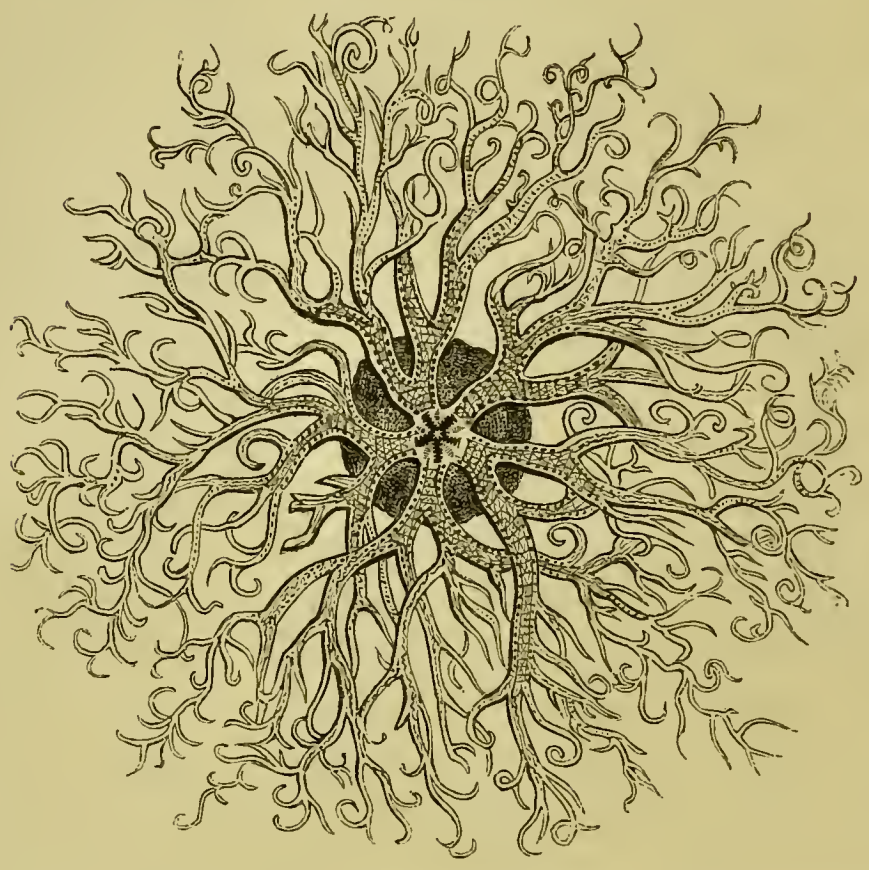
* History of British Star-fishes.

joining the *Comatula* and *Worm*, by intermediate links, presenting an unbroken series, as of establishing the wildest and most visionary theory that ever yet was broached. But let us try, and we shall learn at least one lesson from the experiment—shall feel that, wherever we look, amid the immensity of Nature, there is a unity of purpose evident throughout that stamps each fraction, though it may appear dissimilar at first from all the rest, as being a part "of one amazing whole," designed and perfected by the same boundless wisdom and almighty power. The law of their development in the *Echinodermata* is simply this:—as we advance from humbler to more exalted genera, the flower-like rays are slowly made less complex in their structure till at last they disappear: on the other hand, the central part, or body of the animal, as it increases in perfection, grows proportionately in relative size; the radiating parts being thus obliterated, while the central one, at every step, assumes additional importance. Keeping this principle in view, we now proceed to trace the sequence we have promised.

The Head of Medusa (*Astrophyton*) (fig. 85) differs from *Comatula* in the arrangement of its rays, as well as by the greater relative perfection presented by its central portion. The tentacles are here not fringed with lateral branches, but each stem divides dichotomously into smaller and still smaller twigs, which terminate at last in living tendrils, which it winds around the stems of sea-weeds, climbing thus amid the tangled wilderness, where it resides, or, intertwining all its curly cords, forms for itself a net to

catch its prey, which, once involved, among their folds, must find escape from such a grasp a matter of some difficulty.

Fig. 85.



The *Ophiuridæ* conduct us one step further; here the rays are found no longer double as before, but each presents a simple stem, jointed and flexible, covered with scaly plates, and not inaptly comparable, from its whole appearance, to the tail of a small serpent, hence, indeed, the name applied to all this family. The lateral plates still found on every ray are moveable, and, doubtless, act the part of oars, while, from their length and pliability, the arms may yet be used to crawl about upon the sandy bottom of the sea.

One striking circumstance connected with the history of these snake-rayed Echinoderms, has earned for them the name of "brittle-stars." So fragile are their locomotive rays, that it is difficult to obtain a perfect specimen, even when alive. Not only are they fractured by the gentlest handling, but, strange to say, the creatures will themselves break up their

Fig. 86.

limbs to fragments, as though bent on self-destruction. Professor Forbes,* in his description of a kindred genus (*Luidia*), narrates, with his accustomed humour, an instance of this singular proceeding, which we must give in his own words. "The first time," says this indefatigable naturalist, "that I ever took one of these creatures, I succeeded in get-

* British Star-fishes, p. 138.

ting it into the boat entire. Never having seen one before, and quite unconscious of its suicidal powers, I spread it out on a rowing-bench, the better to admire its form and colours. On attempting to remove it for preservation, to my horror and disappointment I found nothing but an assemblage of rejected members. My conservative efforts were all neutralized by its destructive exertions, and it is now badly represented in my cabinet by an armless disk and a diskless arm. Next time I went to dredge on the same spot determined not to be cheated out of a specimen in such a way a second time, I brought with me a bucket of cold fresh water, to which article star-fishes have a great antipathy. As I expected, a *Luidia* came up in the dredge a most gorgeous specimen. As it does not generally break up before it is raised above the surface of the sea; cautiously and anxiously I sunk my bucket to a level with the dredge's mouth, and proceeded, in the most gentle manner, to introduce *Luidia* to the purer element. Whether the cold air was too much for him, or the sight of the bucket too terrific, I know not, but in a moment he proceeded to dissolve his corporation, and at every mesh of the dredge his fragments were seen escaping. In despair I grasped at the largest, and brought up the extremity of an arm, with its terminating eye, the spinous eye-lid of which opened and closed, with something exceedingly like a wink of derision."

In explanation of the latter part of this most graphic extract, we may here observe that, at the end

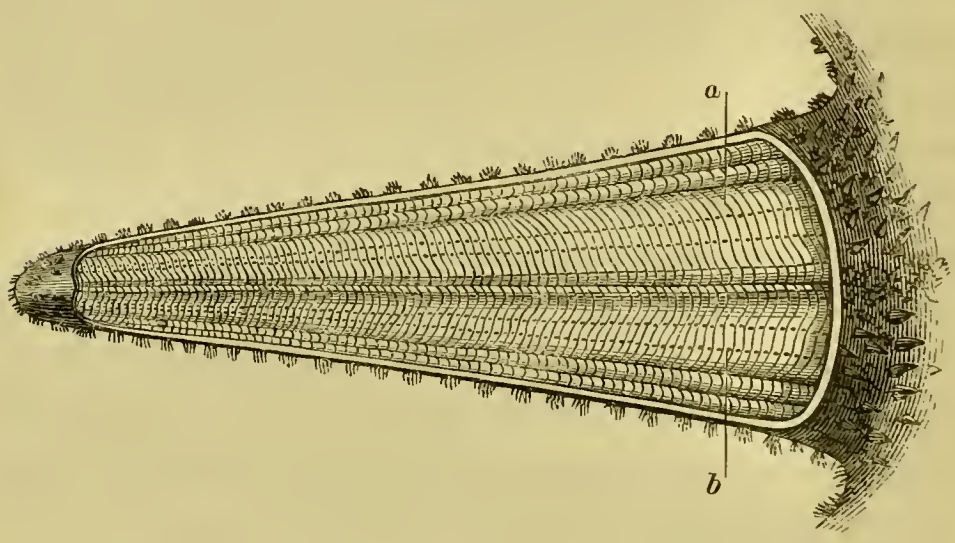
of every ray of many star-fishes, red spots are visible, surrounded with some prominent spines; to these, as in the lower animals, it is the fashion now to give the name of *eyes*, though, for what reason it is difficult to say, since nothing in their structure has as yet been pointed out to entitle them to such a designation:—perhaps the power of winking so facetiously, described above, may give additional weight to their asserted claims to be regarded as true visual organs.

The process of self-fracture is dependant on the imperfect power these creatures have of governing the movements of their irritable skin, which is the moving agent, consequent upon their not having as yet a brain developed able to control the action of the muscular envelope, which, being once over-stimulated, contracts in every part until it breaks in pieces all the limbs,—an accident, however, not so tragical as we at first should fear, for in the star-fishes the limbs will sprout again and grow, a faculty they all possess in common with the polyps.

Still it will be perceived that, in the *Ophiuridæ*, although the central body has assumed so much importance that the rays are but appendages thereto, the latter are so flexible as to be used as legs, and form the locomotive apparatus. In the next race we notice, they become, as it were, confused with the body of which they seem to form a part, and though still so constructed as to bend, and, to a certain extent, to grasp their prey, no longer can be deemed the instruments of motion, hence a new and wonderful addition to their structure is required

to compensate for their stiffness. But before we enter more minutely on the history of the proper star-fishes (*Asteriadæ*), let us take a general survey of their habits, and the duties unto which they are appointed. Their forms are known to all who ever visited the coast; we find them thrown on every beach by dozens, where they lay unnoticed and neglected; few, indeed, among the passers-by, dream that such helpless creatures as they seem to be, rude

Fig. 87.



and unshapen lumps, contain more exquisite mechanism than fancy could imagine. Alas! how often do we find the miracles of Nature thus displayed in vain!

But let a star-fish thus picked up be placed in some transparent pool left by the tide, within a rocky basin; watch it there, and, doubtless, soon the most incurious looker-on will find himself compelled to gaze in mute astonishment at what he sees. From the inferior surface of each ray, the

creature, which before appeared so helpless and inanimate, slowly protrudes numbers of fleshy tubes, which move about in search of firm holding-place, and soon are fixed, by means of little suckers at the end of each, to the smooth surface of a neighbouring stone, or, if the star-fish has been placed in a glass filled with salt-water, to the inner surface of the glass, where every movement may be plainly seen. When these have laid fast hold, others appear in quick succession, and likewise are attached to the smooth surface, till at last hundreds of little legs, for such these suckers seem, are actively employed, and by their aid the creature glides along with such a gentle motion, that it seems rather to swim than crawl.

Thus roused into activity we watch its movements, and perceive that it has appetites and instincts which direct its course. Place within its reach a piece of tainted fish, or other sea-side carrion, and it soon will find it out, and, clasping it between its rays, will swallow and digest it in its ample stomach. So strong, indeed, is its predilection for such garbage that we have frequently, when fishing in secluded bays and creeks, wished heartily they would suspend their vigilance, for scarcely could our baited hooks sink to the bottom, ere we felt a "bite," and, hauling up the line continually, caught star-fishes until our patience failed.

But still a lesson may be taught even by this disappointment. What are these Star-fishes? what is their office or their use in Nature? We speak not now of their minute economy, *that* we shall

scan hereafter. Roughly regarding them we see at once, that they consist essentially of hungry stomachs packed in boxes, and conveyed from place to place by countless legs, in search of offal which they hunt with ceaseless diligence. We see, at once, that they are scavengers employed in Nature's grand police: for Nature has her agents everywhere dispersed, each with appropriate offices assigned, and, day and night at their appointed posts, they punctually perform their rounds.

The Hyæna prowls the desert to remove the putrifying carcases of animals that perish there: the Vulture smells far off the tainted air, and hastens to perform the task imposed on her. Myriads of watchful emissaries scour the earth employed in this important duty.

Is the shore to be without its cleansers, whilst each wave brings with it multitudes of carcases, which, did they but accumulate, even for a little time, would render every beach a putrid heap? certainly not. Nothing is more conspicuous to the observant eye, than the amazing cleanliness that everywhere exists. Death and corruption are as widely spread as animal existence; yet, constantly, the mighty wreck is cleared away and all is freshness, purity, and health.

The *Asteriadæ* assist in this great work, and near the shore destroy what else might taint the land. A humble occupation! left, we might infer, to creatures the most rude and most abject; but here we should be grievously mistaken. Man, it is true, employs simple machinery for simple

work; but not so Nature—to Omnipotence all things are simple! and, perhaps, of this grand truth no better proof could be adduced than we derive from these despised Star-fishes.

The skin, or outer covering, that encrusts the body of the *Asterias* is a tough and fibrous membrane, coloured externally, with various hues of red or yellow, violet or purple, according to the species, and containing in its substance gritty particles. This living tegument, dense as its structure now becomes, is still the representative of the external living crust that coats the cortical polyp or the encrinite, and, being contractile, serves to bend the rays and moveable spines as far as motion is allowed. Neither has it lost the power of forming, and depositing within itself, a dense calcareous skeleton; but, on the contrary, performs this function with such admirable exactness that all the skeletons we yet have seen, either among the polyps or phytocrinites, fall into insignificance in point of structure and completeness, when compared with that which forms the framework of a star-fish. Thousands of separate pieces here are found moulded with perfect accuracy, in various shapes, and fitted to each other as by joints, with such exactitude, that every ray appears a masterpiece of mechanism. The upper part, or arched vault that covers in the back, is propped by numerous interlacing bands of earthy matter, forming in the substance of the integument a kind of stony net-work; but, in the floor of every ray the pieces of the skeleton assume a far more regular arrangement, such as is displayed in the appended figure

(fig. 88). Along the middle run a double row of arched *vertebræ*, (such is the name they bear,) all meeting in the centre, every separate piece being fitted, with the utmost care, to those contiguous to it, and allowing, from the manner of their junction,

Fig. 88.

some extent of motion. Numerous as are these vertebræ they form but a small part of the elaborate structure; at their sides are others, in still greater number, all adapted to the rest with wonderful precision; and altogether forming such a spectacle as quite defies the pencil to delineate its beauty. Countless as are the vertebræ each piece is per-

forated with one or two small orifices (two in the specimen here drawn (*Asterias Rubens*), through every one of which, during life, a locomotive sucker is protruded at the creature's will; thus, from the number of these little holes, the reader may appreciate the multitude of ambulatory organs, before briefly noticed, but which now claim to be examined more at leisure.

In order to explain the nature of the sucking legs, which will be found, not only in *Asterias* but in more elevated forms hereafter to be noticed, acting important parts in the economy of the Echinoderms, we have prepared a diagram exhibiting a Star-fish cut in two, so as to display its inward parts and represent the suckers as in action.

Along the floor of every ray, and corresponding with the little holes above alluded to, is placed an equal number of transparent vesicles (fig. 88, *b*, *v*, *v*), which, when examined from within, resemble rows of little pearls. To every vesicle, and there are hundreds of them in each ray, a sucker is attached, which can be made, at will, to issue through the corresponding orifice and be placed in contact with external substances. To explain the mechanism whereby this is accomplished, a diagram is given upon a larger scale (fig. 88, B, *a*), which represents the whole machinery. The vesicle itself (*a*) is a contractile bladder, which, for illustration's sake, we here may call an India-rubber bottle with its neck stretched out into a long and fleshy tube (*b*), which passes through the shell and ends in an expanded sucker (*c*). The vesicle is filled with fluid, and when

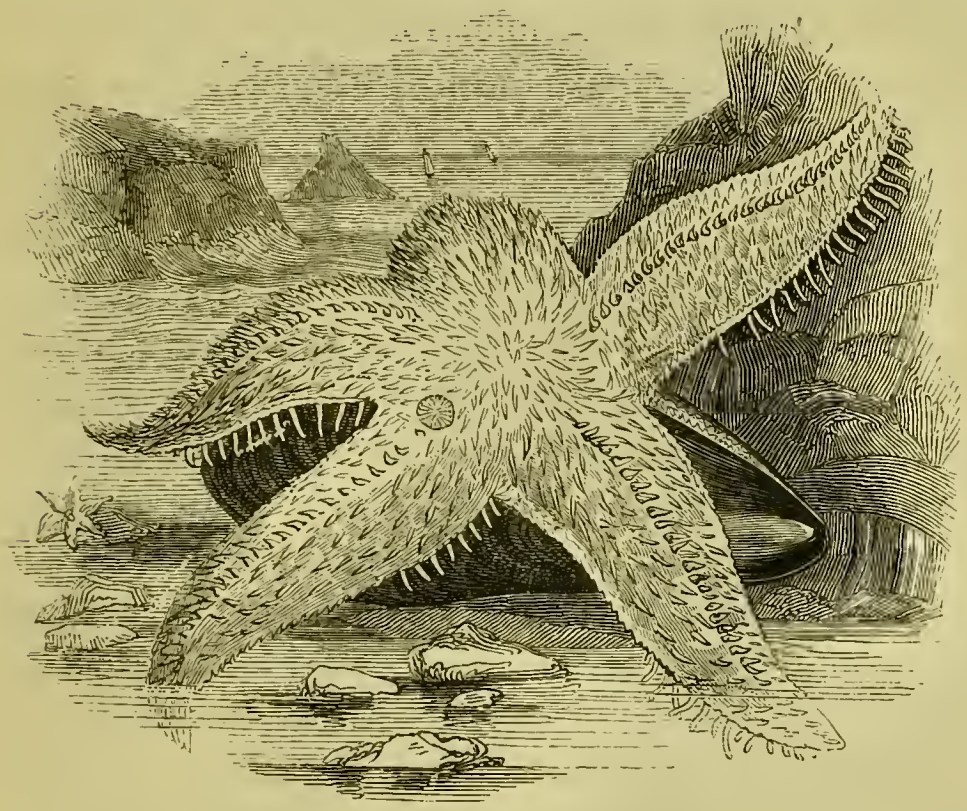
it contracts, it forces out the liquid it contains into the fleshy foot (*b*), which, thus made tense, stands forth erect, and stretches out the appended sucker to a distance, in proportion to the pressure exercised. Does the star-fish wish to loose its hold, and draw its suckers back, the muscular stem (*b*), contracts in turn, drives back the liquid it contains into the vesicle, and shrinks till it is scarcely visible. In the diagram, these different states are shown (1, 2, 3), the legs being there exhibited in different states of tension and contraction.

Numerous as are the locomotive suckers, every one is perfectly subject to the control of the Asterias; one alone may be projected, or a few may act in concert, or the entire set be put in motion, and directed so that they co-operate most perfectly in seizing prey, or in effecting locomotion: such consentaneous action is, indeed, by no means the least curious feature of their history, seeing that no brain, or common ruling centre, yet exists to govern and control their movements.

Examining the viscera contained within the shell, we first perceive a most capacious stomach (fig. 88, A, *a*), filling up the central part; the sides of this large stomach are, moreover, thrown into innumerable folds, which indicate, apparently, a power of undergoing enormous dilatation, as though destined to take in large quantities of food which, doubtless, is the case. But there is still another reason why the walls of the digestive cavity are thus extensive, seeming, as they do, quite disproportioned to the size of the Asterias. These creatures, though they

eagerly devour all sorts of offal, sometimes shew a more refined appetite, and when the opportunity occurs, they greedily attack shell-fish of various kinds, muscles, and little whelks, but more particularly they seem to relish oysters, and the havoc they commit on oyster beds is so notorious, that the fishermen

Fig. 89.



destroy them without mercy. Strange creatures, these, to appreciate so delicate a banquet! How do they obtain admission to their prey? They obviously possess no oyster-knives, or other weapons of that nature. The ancients, thought, indeed, they could effect an entrance by stratagem, and tell us how they wait most patiently until the oyster chance to gape, when, cunningly, they thrust the extremity

of one of their hard rays into the opening, and having thus obtained an entrance, force their way by slow degrees into the otherwise impenetrable citadel, and so obtain their prize. Whether, in former times, the star-fishes adopted this proceeding we will not inquire, but sure we are, that at the present day, they do not practise it. Again, their mouths are so diminutive, that to take in an oyster whole, is quite impossible, for in the largest star-fish it will scare admit the little finger. The mode adopted is, in truth, unique; the Asterias, finding it impossible to manage otherwise, seizes upon the shelly valves of its devoted victim, and proceeds coolly to turn its stomach inside out; it then, perhaps, instils between the shells some torpifying fluid, which deprives the oyster of its strength, and soon compels its prey to open its defences. The stomach of the star-fish, now distended like a bladder, is pushed in, and made to enwrap the oyster, which is soon digested, even in its own shell, and furnishes a meal for its uncourteous visitor.

To the wide bag that forms the proper stomach, there are appended ten capacious organs (88, A, *f*), two of which are placed in every ray. Every one of these is a closed sac, composed of membraneous walls, so folded as to form a most extensive surface, over which innumerable veins are seen to ramify. A narrow tube (*e*), leads from the stomach into each of these appendages, through which the products of digestion, the pure nutriment derived from the food alone, can pass into these delicate re-

servoirs, prepared for its reception, from which the vessels suck it up, and carry it to all parts of the system.

Beneath the stomach, in the angles formed by the conjunction of the rays, are found ten bundles of long branching tubes (fig. 88, A, *o*), in which the eggs are formed. At certain seasons, these are found quite full of orange-coloured granules. These are eggs, the germs of a new race of star-fishes, and, when mature, they are expelled into the sea through little apertures placed round the mouth. Hundreds of eggs are formed in every bunch of tubes, so that a single individual will furnish thousands in one season; and when we calculate the numbers of these creatures met with on the shore, all equally prolific, we again are tempted to inquire, How is it that the sea is not soon filled with star-fishes? Here, again, we find another instance of the boundless providence of Nature, forming thus, exhaustless stores of food, destined to be the nourishment of far more elevated beings, which, without such aid, could not exist, or if produced, would perish speedily for lack of sustenance. The Asteridæ, besides performing their appointed work, with silent but unwearied diligence, are also made subservient to another end of scarcely less importance, and are placed among the living granaries of the deep.

Proceeeding onwards now to other genera of the Echinoderms, we yet perceive the change of form advancing step by step, the central part continually assuming more importance as the rays are slowly lost. The radiating arms, even in the *Asterias*, were

shortened, so that all the flower-like form of the *Comatula* was lost, and to supply their want of flexibility, the sucking discs, or ambulacral feet, were indispensable; another step, and even the little power of motion yet remaining vanishes, as in the *Asterina* (fig. 86, *b*), where the rays become so stunted that all movement is impossible, except what is performed by the retractile legs that are protruded from the under surface of the rays. In the *Palmipes* (fig. 86, *c*) the body has encroached so far upon the rays, that they seem wholly lost, or are but indicated by the angles of the flattened body. And now we enter on another and a very different type; for, having lost the rays, the angles too at length become obliterated: the whole body takes a circular, or shield-like form (fig. 86, *d*), on which, however, we still find the radiating lines of orifices, whence the locomotive suckers are protruded. In these Echinoderms (*Clypeasteriæ*), the body is a flattened box, composed of numerous calcareous pieces, accurately joined, and covered on the outer side with numberless minute crystalline spines, which all being moveable, are used for locomotion. We pass from these to the *Spatangi* (fig. 86, *f*), where the external shell assumes an ovoid shape, and thence proceeding, we arrive, without an interruption in the series, at the *Echinidæ*, *Sea-urchins*, or *Sea-eggs*, as they are named, in which the radiated form seems wholly lost, and the calcareous crust is more or less transformed into a globular case of most surprising workmanship (fig. 86, *e*). Here we will pause again, in order to examine well the structure and the history

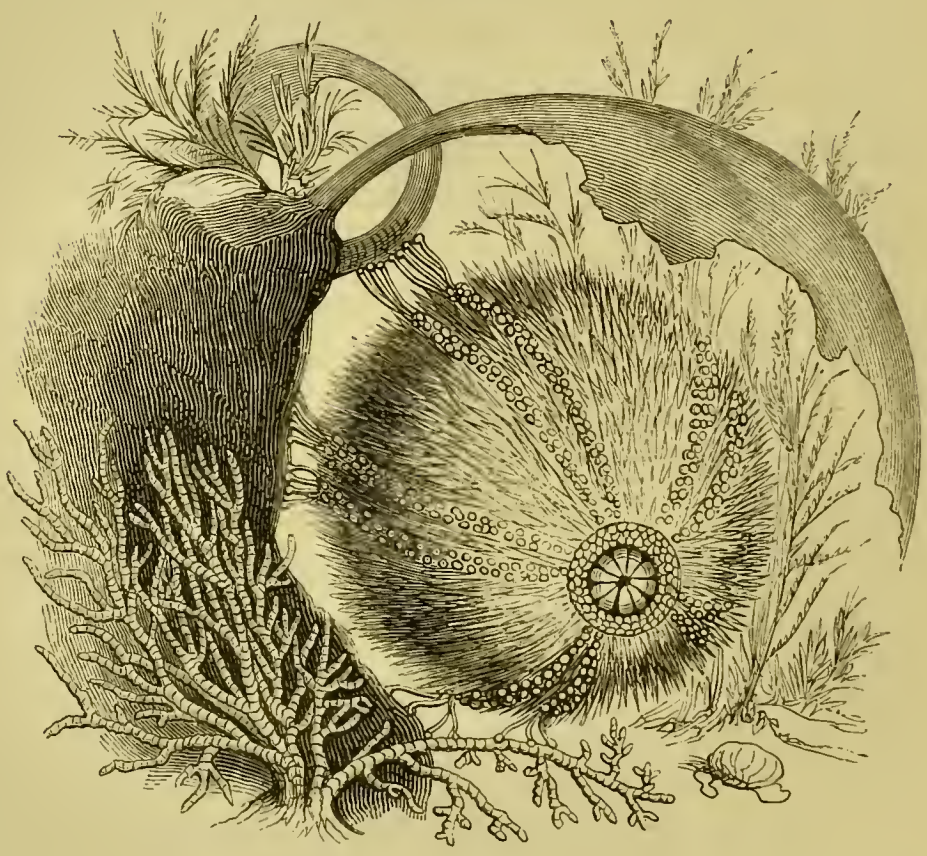
of animals so far remote from any that we yet have seen. But while we take the Echinus, properly so called, for special illustration, as being the most complete or typical of all the group, let it be understood that, with slight modifications dependent on the varying shape of different genera, the observations we shall have to make apply to all the shell-cased species, whether they be flat, oval, or round, their means of locomotion being essentially the same, consisting both of suckers, such as we have seen in star-fishes, and also of innumerable spines of various size and shape, but all attached to the shell with admirable skill, and moved by most elaborate mechanism.

The *Echini* may be found in abundance upon our coasts, inhabiting the sea not far from shore, or lurking among rocks, where they obtain the means of sustenance. Their shape is more or less completely globular (fig. 90), and their whole surface covered with strong spines, on which they roll themselves about from place to place, moving them all as though they were stiff legs; but if they wish to hide themselves from observation, or perceive they are in danger of being left upon the shore by the retreating tide, these numerous spines perform the part of rakes, and scraping up the sand, soon make a kind of grave into which the creature sinks, till it is covered over, securing for itself, by this proceeding, safety from external violence, and also water to respire until the tide come back.

Such power of *walking* in an animal that is enclosed on all sides in a shelly box seems, in itself,

sufficiently surprising, but when we learn that it can climb the cliff in search of food, and even make its way, while pendent from the roof of rocky caverns, we scarcely can conceive the possibility of its performing feats so difficult, and eagerly inquire what means have been provided for the purpose.

Fig. 90.



Whoever takes the trouble to observe the *Echinus* while alive, confined in fresh sea-water, or at large upon its native rock, will not be long in doubt upon this point. Protruding from the shell, and reaching past the points, even of the longest spines, appear innumerable suckers, evidently similar in their construction, and in function too, to those of the

Asteridæ. These are applied in turn to the smooth inner surface of the glass, or to the stone whereon the creature climbs, and by the aid of this elaborate mechanism the *Echinus* glides along to browse the corallines, and other zoophytes, which clothe the rocky reef, or sea-girt precipice. The creature's mouth is carried next the ground; it is a circular orifice, surrounded with a fleshy ring, through which protrude five sharp crystalline teeth, whose points all meeting in the centre serve to nibble off the substances employed as nutriment, and thus, without apparent instruments of sense, such as belong to higher animals, and unpossessed of limbs except its spines and suckers, the sea-urchin marches on with ease, in situations where, apparently, no footing could be found, and lives a life of indolent security encased in solid armour, and beset with spines, compared with which the bristles of the hedge-hog are a poor protection.

Such being the general habits of the *Echinidæ*, our next inquiries must relate to their construction, and perhaps we are already prepared to expect that this must offer many features worthy of remark.

The shell, or dense calcareous crust, that seems to enclose the animal, is really placed internally, for although it contains the viscera appointed for nutrition, all the living flesh, the real substance of the creature, is external to it. Let this fact be well remembered if we would appreciate the analogies which still ally these globe-like beings to the star-fishes, and through them to the polyps.

The shell, in the fresh animal, is covered over with a thin fleshy skin filled with calcareous points. This skin is fibrous and contractile, being, in truth, the representative of the soft fleshy covering that encases all the branches of an *Encrinite*, and which, in *Asterias*, moves the rays and spines. It is, in fact, the animal itself; it forms the shell within, and likewise wields the external organs, the stiff prickles, when employed as instruments of locomotion. Though more distinctly muscular than in inferior zoophytes, and, consequently capable of contracting more energetically, it retains the power of separating earthy matter from the sea, wherewith it moulds the shell that gives it shape, and also constructs the countless spines that stud the outer surface of the body, all which are built by slow precipitation of calcareous particles secreted by the living skin itself.

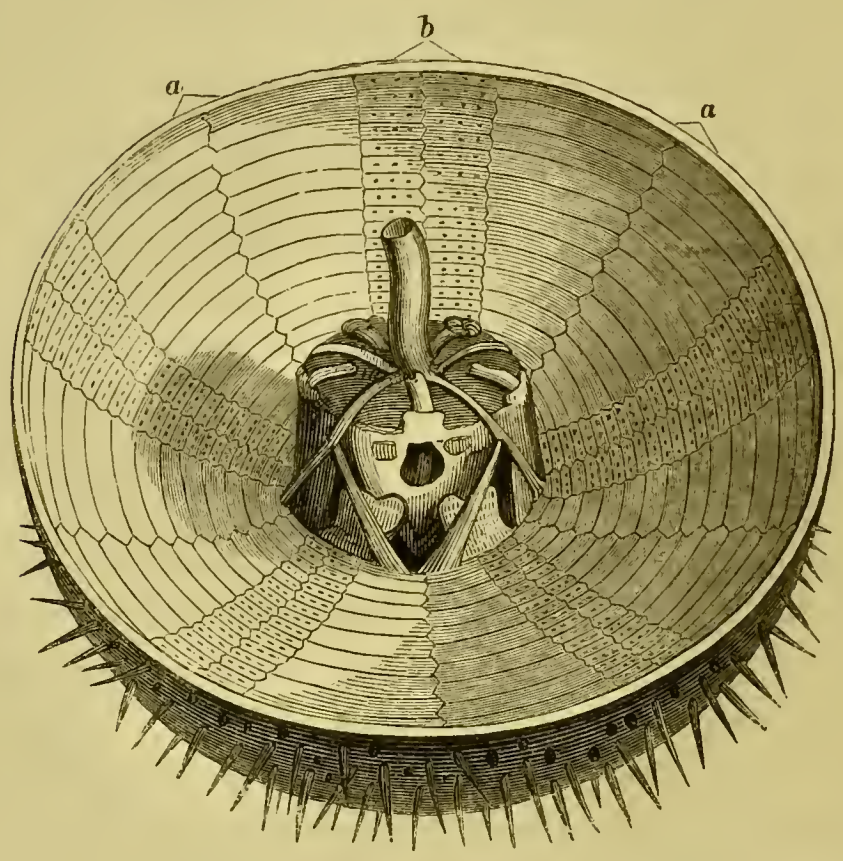
Immediately beneath the living tegument is placed the shell, itself a structure, perhaps, the most elaborately framed of any we have had occasion to allude to: a piece of workmanship so exquisite, so far beyond all human art, so visibly demonstrating sovereign skill and boundless wisdom, that a sense of awe creeps over the mind as we proceed with all humility to contemplate so great a miracle. And here we may observe, that such examples of contrivance and of obvious intention as are frequently displayed in what may well be termed the ruder mechanism of nature, often come with greater emphasis upon the heart, than all the more mysterious wonders that abound in natural science. The physiologist, perceives at every step, proofs of design which baffle human

comprehension, but the ideas they raise are vague and undefined, and so, of course, the application too is indistinct; but when we can from first to last perceive the end in view, and understand the means of its accomplishment, the mind is satisfied, and owns at once how great the foresight and how grand the power of the Supreme Designer.

The crust of the *Echinus* when denuded of its spines, and stripped of its external covering, would seem to be an ordinary shell, having its outer surface covered over with polished tubercles, regularly arranged. Of these, the largest are disposed in lines that pass from pole to pole of the round box, like lines of longitude upon the globe of the geographer. Intermixed among the larger tubercles are seen innumerable smaller eminences of similar construction, but dispersed with less precise arrangement, upon all of which, when in a living state, spines were attached in correspondent number. Moreover, placed at intervals between the spine-crowned tubercles are ten broad bands disposed in pairs, all pierced with countless holes; these, too, extend from pole to pole of the round box, and through them, during life, the locomotive suckers passed, already noticed as being used for climbing rocks or for attachment to some foreign body. On cutting through the shell so as to see its inner surface, we perceive, to our surprise, that far from being, as it appears externally, a simple shelly exudation moulded to the form of the *Echinus* like the shells of lobsters or mollusca, it is a very complex fabric built with most consummate art, consisting of some thousand

pieces varying in size, but shaped with mathematical precision, and conjoined with so much accuracy, that the eye can but with difficulty trace the lines of

Fig. 91.



union. Tell a human artizan, however versed in geometrical proportions, to cut out a thousand plates polygonal in form and fit them to each other, leaving not the slightest space between their margins anywhere, so that the whole shall form a hollow sphere of certain given proportions,—how would he succeed? Doubtless he would pronounce the problem quite impracticable. But in the shell before us this is just what Nature has achieved most perfectly. First, we observe five double rows of oblong

plates (fig. 91) pentagonal in form, which on their outer surfaces present the spine-supporting tubercles. On either side are found innumerable pieces of a smaller size, but equally exact in shape, through which are bored the perforations for the ambulacral feet, and these again are separated from another row of perforated plates by other intermediate pieces having spines affixed externally. These plates are mostly pentagons in form, with sides of various lengths, but all combined fit each other so closely, that their combination seems to form one solid compact shell.

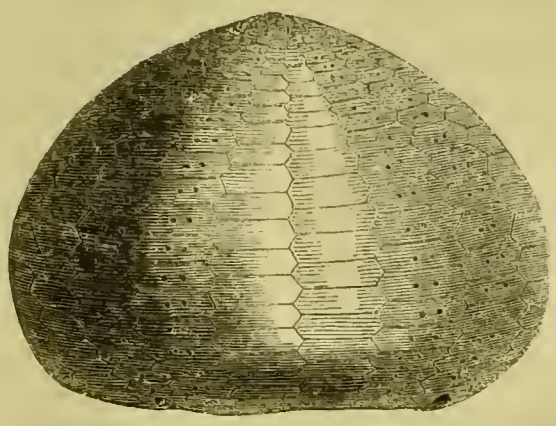
We shall not stop to count the number of the plates comprised in every series, or to calculate how many perforations are provided for the feet. Let the reader try to number them when opportunity occurs, though here numbers are of little consequence. Let us rather ask why Nature, in this case, has chosen to work by laws so complex, when we might suppose a simpler fabric would have done as well—why frame a shell composed of thousands of small portions thus connected, when even in higher animals all this elaborate device can be dispensed with? A little thought will soon convince us that, even here, as elsewhere, Nature has employed no useless superfluity of structure. To case the animal in stone would have been a simple process; as we have already seen that almost all the zoophytes secrete calcareous matter in abundance; but, when thus closed up in a stony shell, how could the creature grow? Here is the difficulty. We might as well expect a Chinese lady's foot to grow while shod in iron, as that the *Echinus* should

expand from the small size it first presents to its adult dimensions without some remarkable provision being made to allow of such increase. Growth constantly goes on, and yet the crust itself, being, when once formed, devoid of life, and as incapable of growing as if made of marble, cannot expand as do the bones of higher animals,—neither is any part left soft, but at all ages the whole shell has the same compactness and solidity throughout, and presents the same precise distinctive form peculiar to the species. The only way in which this difficulty could be met is obviously that which Nature has adopted. The shell is made of numerous pieces, between the contiguous margins of which the shell-secreting tegument dips down, adding continually to *the circumference of every piece* cretaceous particles layer after layer, by which the superficial size of each progressively increases, whilst its form remains unchanged. The thousand pieces that compose the shell thus simultaneously become enlarged, and, as they never change their figure or the relative proportions that they bear to all the rest, the entire shell expands without the slightest deviation from the given form, till it attains the limit of its growth.

From their dense structure, we might naturally expect that these elaborately formed Echinoderms, when buried and thus secured from mutilation, are almost imperishable. Their shells exist abundantly in divers strata of the earth, and from our chalky cliffs innumerable specimens may be obtained of forms long since extinct, and races that have perished so completely as to leave no living representa-

tives behind. The genera, indeed, are different, but their shells, the embalmed mummies of a former world, exhibit the same wondrous mechanism as those which now frequent our shores (fig. 92), and testify that, though the land and waters of our globe may change, though continents exist where once the ocean rolled, and seas now occupy the place of countries that have perished, the same unchanging Wisdom still presides, and works by laws fixed and immutable.

Fig. 92.



But leaving now the shells of the *Echini,* in themselves so worthy of our admiration, we must next examine the elaborate apparatus given for locomotion, and describe the countless spines distributed in such profusion on the exterior of these animals. No sooner had the rays of the *Asteridæ* entirely disappeared, than some arrangement was imperatively needed to supply the place of those important organs, and accordingly, the spines, as we have seen, were substituted for them. Thousands of these stiff prickles stud the surface of the shell, to which they are all fixed by ball and socket joints, on which they move as on a pivot, and become, in fact, so many legs, whereby the creature rolls upon the shore, and walks, supported by its numerous stilts, with a facility we scarcely could expect from the apparent clumsiness of such complex

machinery. Examine well these spines; be not content with superficial criticism: take the microscope and study them attentively; mark their varied shapes, their fluted ornaments, and all the external sculpture they exhibit. Cut them in slices and thin segments to display their inward structure; see the exact arrangement of each crystal molecule of which they are composed, the mathematic skill conspicuous in every part; lastly, compute their numbers, and then perhaps you will be tempted to exclaim in the words of a recent writer, "Truly the skill of the Great Architect of Nature is not less displayed in the construction of the sea-urchin than in the building up of a world."

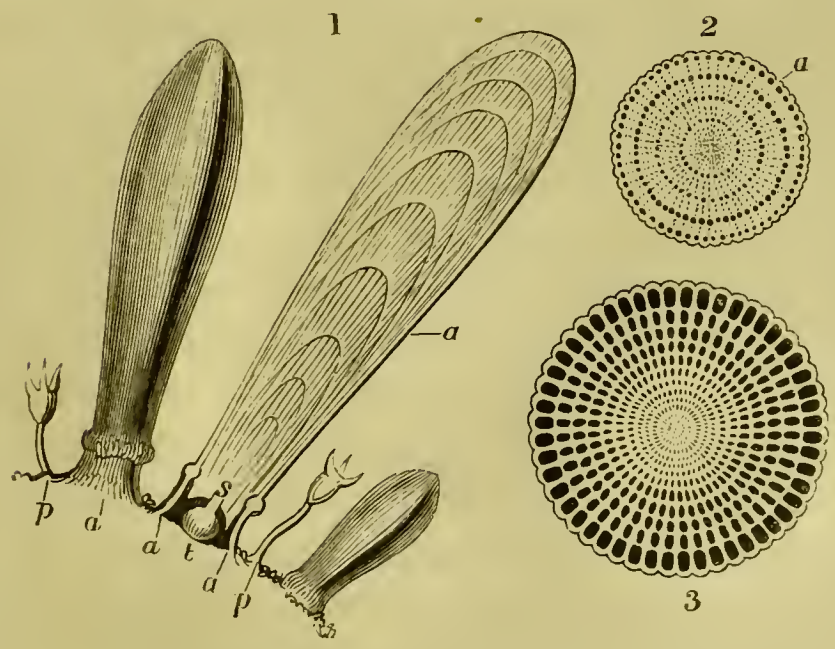
The base of every spine presents a smooth concavity, or polished socket, which exactly fits one of the rounded tubercles already pointed out, upon the outer surface of the shell, and forms a perfect joint. No matter how minute the spines, be they as thin and delicate as the fine pile of velvet such as exist in *Clypeaster* and in other flattened genera, or large and club-shaped, as in *Cidarites*, the joint is equally complete and moveable in all required directions. In the last-mentioned race, indeed, we see additional provision made to give secure attachment,—the centre of each tubercle being furnished with a little pit, from which arises a strong ligament that is implanted in the base of the appended spine to obviate all chance of dislocation.

To understand the mode in which the spines are all produced, and fixed upon the body of the *Echinus*, we must again refer to the soft tegument

whereby the numerous pieces of the shell are all secreted. This skin, which is, in fact, the living substance of the creature's body, likewise constructs the spines, and if a section is prepared of one of these taken from a recent specimen, each will be found encrusted over with a layer of this soft fleshy membrane, as were the stems of corals, or *Gorgoniæ;* and in like manner the investing film is able to secrete cretaceous particles, which are arranged, *stratum* investing *stratum*, with such art and regularity, that few more beauteous objects can be found than one of these neglected spines.

The attempt is vain to imitate the extreme precision visible in the construction of the weapons thus provided for each tribe or even species of the

Fig. 93.



Echini. Still we have rudely sketched in the annexed figure (fig. 93 2, 3), two transverse sections

taken from different genera merely to give a rough idea of the structure they display internally. The upper figure (2), displays a slice transversely cut from the large spine of *Cidaris*, but little larger than the natural size; the particles composing it are seen arranged in regular lines that radiate from the centre to the external skin (*a*), by which they were deposited, while, at due intervals, concentric rings of dark green spots, which, when examined with the microscope, appear like glittering emeralds, pointing out the periods of growth, each circle having been in turn the outer stratum of the spine.

The lower figure (3), exhibits the appearance of a transverse section of the spine of the *Echinus* seen most commonly upon our shores, when magnified with a low power. Would that our pen or pencil could at all do justice to its most elaborate construction. Its growth, however, is most obviously accomplished, as in the former instance, by concentric layers of new material being deposited successively around a central nucleus by the living skin: but how deposited? What elegance! what art! what exquisite design! What mathematics are conspicuous throughout the tiny fabric! And yet this spine is only one among the thousands equally beautiful that crowd the back of the *Echinus*. Can man compare the proudest works of human art with what he finds even in the humblest worm? There is at least this difference conspicuous—this grand distinction—man perforce applies comparison to all the labours of his industry, and says one work of ingenuity is good, another better, as it more or less

completely answers the design intended; but creation knows of no such grades,—here everything is perfect, best, completest.

To explain more accurately their mode of growth, the reader is referred to the same figure (fig. 93. 1), where the spine of *Cidaris* is shewn divided longitudinally to display its interior and the construction of the joint described above, by which it is connected with the shell. The living covering of the shell (*e*) passes at (*b*) over the ball and socket joint (*e*, *f*), on to the spine (*a*), which it entirely covers whilst the growth continues; layer by layer it keeps depositing the earthy matter it secretes on the exterior of the spine, leaving, at fixed intervals, concentric rings, as shewn in all three figures, indicating thus repeated stages of increase, such as are evident in transverse sections of exogenous trees, the growth of which, indeed, most aptly illustrates the process.

Dispersed over the surface of the body, there are found, on most of the *Echinidæ*, great numbers of minute appendages of very singular aspect, which have been called by naturalists *Pedicellariæ*, but what may be their nature is as yet a subject of dispute.

These extraordinary appendages to the integument of the *Echini*, two of which are delineated in a preceding figure (fig. 93. 1, *p*), resemble in their shape minute polyps, each consisting of a delicate flexible stem, and a little bell-shaped body generally surmounted by three prong-like tentacles, which open and shut by movements apparently of a voluntary

character, and which are easily excited by the application of a stimulus. The real nature of these irritable structures is, however, by no means satisfactorily determined, and indeed many naturalists, even in the present day, persist in regarding them as distinct and independent existences, to which they have given the name of *Pedicellariæ*, regarding them as parasites that infest the integument of the *Echinodermata* in the same way as the *Epizoa* attach themselves to the external surface of other marine animals. Their structure, indeed, is extremely remarkable, and forcibly reminds us of that of an *Encrinite* of extremely simple construction. The stem contains a hard calcareous axis, which is covered with the living fleshy envelope, and, according to M. Sars, is articulated at one extremity to a little tubercle, or barb, which projects from the shell of the *Echinus*. The moveable prongs are likewise supported by a kind of calcareous skeleton, and moreover edged with small teeth. Such is their irritability, that a pin, or other foreign body introduced between the prongs, is at once seized and held so firmly, that, if the *Pedicellaria* be broken off from its attachment to the *Echinus*, it may be lifted out of the water rather than relax its grasp. But still the problem remains to be solved. What can these *Pedicellariæ* be? Are they organs belonging to the *Echinus*, or are they foreign bodies merely parasitically adherent to it? M. Sars adopts the former opinion, and gives the following reasons in support of his views upon the subject.

First, that *Pedicellariæ* are found on all Sea-

urchins without exception, and under the same circumstances, which certainly would not always be the case if they were parasitical animals; just as the *Epizoa* are not always met with on all fishes, or other animals which nourish them.

Secondly, M. Sars conceives, that the *Pedicellariæ*, with their calcareous stem, resemble too nearly the spines of the *Echinus*, to be allied to any animal of the Polyp kind; neither have they any mouth or digestive cavity, such as they might be expected to have if they were independent creatures.

Thirdly, that the *Pedicellariæ* are firmly fixed in the skin which envelopes the whole Sea-urchin, upon a very small projecting knob of the shell, to which knob they are very strongly attached, but yet moveable like the proper spines, the lower extremity of the stem of the *Pedicellaria* being somewhat hollowed and articulated with the knob; also that when one of the *Pedicellariæ* is torn off, the skin connecting its stem to the *Echinus* is torn at the lower end, evidently shewing an organic connection between the *Echinoderm* and the appendages in question. M. Sars further remarks, that, when the skin of the Sea-urchin, or a single *Pedicellaria*, is irritated—as, for example with a pin, —the surrounding *Pedicellariæ*, which stand in a wide circle, invariably bend themselves quickly towards the irritated part, as also do the spines, clearly shewing that they all feel the irritation applied; although, at the same time, when they are plucked off from the body, they will continue to exhibit independent movements for six hours after their se-

paration, as indeed will any portions detached from the lower *Zoophytes*. Conceiving them, therefore, to be really constituent parts of the animals upon which they grow, and most probably important organs provided for a determinate purpose, M. Sars suggests, that perhaps Nature, who has so abundantly provided the Sea-urchin with such an astonishing number of locomotive spines, and ambulatory suckers, serving the purpose of feet, has given in the *Pedicellariæ* innumerable antennæ, with which to seize small animals, or to lay hold of whatever might approach the sensitive skin covering the surface of the shell, and thus, in conjunction with the prickles, protect it from injury.

In reply to the above deductions which M. Sars derives from his own observations, Professor Forbes, who, of all British naturalists, has paid most attention to this subject, although he fully admits the accuracy of M. Sars' general description of the *Pedicellariæ*, denies that there is a knob on the shell of the *Echinus* for the articulation of each *Pedicellaria* which it carries, seeing that great numbers are not fixed to the shell at all, but to a tough skin that encloses the mouth; and, moreover, he does not admit that the irritation of one *Pedicellaria* affects those in the neighbourhood, unless they likewise are accidentally touched: he considers, indeed, that each is independent of the others as well as of the *Echinus*, and concludes by intimating that he can by no means consider the question of their nature to be settled, and is quite undecided whether they are really organs of

the *Echinodermata*, or parasitic creatures, although he inclines to the former view.*

We have yet to notice the second and by no means the least important set of organs afforded to the *Echinidæ* for the purposes of progression, namely, the ambulacral suckers, which, as already stated, are protruded through the countless orifices disposed in ten broad bands around the shell, passing along its circumference from pole to pole. We have before illustrated their mode of action, and the way in which the sea-egg climbs the rocks by their assistance; and, having seen organs of similar structure in the star-fishes, shall be prepared to understand their structure, and the way in which they execute the offices assigned them.

The suckers of the *Echini*, in all essential particulars, resemble exactly those of an *Asterias*, consisting of long projectile fleshy cylinders, which are protruded and rendered tense by water or some other fluid injected into them, from an apparatus contained within the body. The degree to which the protrusible tube can be exserted will of course differ in every genus in proportion to the length of the locomotive spines, it being absolutely necessary that, however long the latter organs may be, the prehensile portion of the sucker shall be able to reach beyond them; so that in the long-spined genera, of which, in warm climates, some are found having spines several inches in length, the tubes with their appended adhesive discs resemble little cables thrown out to a distance from the

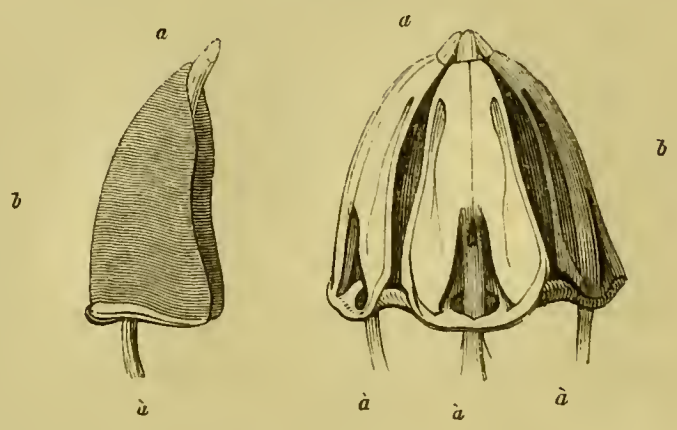
* Forbes' British Star-fishes, p. 160.

animals in order to secure an anchorage, or ropes whereby to hoist themselves from ledge to ledge of the steep rock on which their food is found.

Those suckers that surround the mouth perform, besides, another duty, and may be compared to fishing-lines, ready to seize upon such prey as comes within their reach and drag it to the mouth to be devoured—broken, and crushed, and swallowed, by machinery adapted to such purpose, and contrived upon so strange a plan, that we must next proceed to examine and explain its strange construction.

The mouth of the *Echinus* is a wide aperture, situated at one of the poles of its orange-shaped body, through the middle of which the points of five teeth of enamel-like hardness are seen to project to the distance of a quarter of an inch or so; these are placed in a circle, so that their tips touch each other, and can be made to nibble to pieces whatever is placed between them. Externally they appear to be suspended from the margins of the

Fig. 94.



opening in the shell, by a leathery-looking skin, but on examining the interior of the shell, they are

seen to be fixed in a very curious framework, which in shape somewhat resembles an old Grecian lantern, and has consequently been called after its first describer, *the Lantern of Aristotle.* This lantern consists of five three-sided pieces, arranged in a circle, so that each has two of its sides in contact with the corresponding sides of the two pieces contiguous to it, the whole being bound together by strong muscles, and moved in every needful direction by a very complicated apparatus of levers and ropes, disposed with admirable precision. All the contiguous sides of these five pieces are grooved like files of most beautiful workmanship, and between these ten files every particle of food must pass before it gets into the stomach, so that soft substances are thus bruised and triturated, as by means of a mill, before they are swallowed. But the most important use of this frame-work is to furnish sockets wherein those teeth that project out of the mouth may *grow;* for, hard as their points are, they would soon be worn quite down to the opening of the mouth, by constantly biting such substances as the *Echini* swallow, did their growth not keep pace with their wearing away. Each of these teeth is therefore implanted in a separate socket, and is constantly growing at its root, as fast as it is ground down at its point, which is thus kept always of the proper length, and, from its peculiar prismatic shape, is never blunted by the hard work it has to do. But the most puzzling part of this singular apparatus, which, indeed, is quite unique in the animal creation, is, that notwithstanding the extreme elabo-

rateness of its construction, and the delicacy of the ten files between which the food must pass, the alimentary canal of the Sea-urchins is generally found filled with the most intractable substances, such as sand, and broken pieces of shells and coral, as though these animals were destined to economize the last crumbs that fall from Nature's bounteous table, by extracting, even from the very sand, such particles of organized matter as might still be made available as nutriment; as some worms have to swallow the mould in our gardens, thence to obtain the remnants of decay, that even they might not be lost. Vast, indeed, is the store of food provided for the nourishment of living beings, and we might well suppose that a supply so boundless, and so lavishly dealt out, allowed some waste, and that the leavings of so large a banquet might be left uncared for; but we here perceive how the last morsels are used up, and made the provender of creatures framed to reap enjoyment from the humble meal.

Not less elaborate than the external fabric, is the internal apparatus for diffusing nutriment throughout the system. Blood-vessels are spread like a rich net-work over all the organs of digestion, to take up the nutrient particles, and carry them through every portion of the body, in order to supply each part with the materials for growth. The water enters freely through appropriate apertures pierced in the shell, and, bathing all the included viscera, secures the means of breathing, bringing air to renovate the fluids as they circulate,—a mode of respiration we might suppose of the simplest pos-

sible character. But the apparent simplicity of the process is quite illusory; for when the shell is filled with the requisite quantity of water, what mode is there of changing it and bringing fresh supplies as they may become requisite? Here again we have fresh source of wonder, for the microscope reveals that all the interior of the animal, the lining of the shell and all the viscera, are covered with a countless host of *cilia*, whose incessant movements urge the water onwards in continuous streams, diffusing it in all directions, and of course producing such an agitation as secures constant renewal of the vital element so needful to existence. Thus within, without, in every part of the construction of these animals, we perceive wonders accumulate, until the observant mind is lost in admiration at the thought of so much mechanism being employed in making a "*Sea-egg*."

Having arrived thus far in our examination of the class we are now considering, we find ourselves as remote as possible from the Polyp-forms whence we set out; and should be quite at a loss to connect the globular and shell-covered *Echinus* with the elongated and soft-bodied *Worm*, whose flexible and muscular integument presents no traces either of the radiated form or of the calcareous covering which form such predominant features in the echinoderm races, did we not here perceive Nature beginning slowly to change her plan of operations, and gradually introducing us to another type of organization, through a long series of animals that now invites our attention. These creatures are

grouped together under the general name of HOLOTHURIADÆ; and will be found, notwithstanding their uninviting appearance when casually picked up and superficially examined, to present an organization as elaborate, and to exhibit phenomena as remarkable, as any race of animals we have as yet encountered.

The body of a *Holothuria*, when brought up by the dredge from its native haunts, has very much the appearance of a disagreeable-looking slimy cucumber; and, in fact, the resemblance is such as to have earned for them the general appellation of sea-cucumbers, or sea-gherkins, from the inhabitants of the coast.

When placed in their own element in order to watch their movements,* they are seen, whilst alive and active, to have considerable powers of locomotion. Their skin, instead of being hardened into stone, remains permanently soft and muscular, so that the creature can contract or elongate its body at will, and thus is enabled, to a certain extent, to crawl after the manner of a worm, although its movements are extremely slow and languid. Still,

* It may not be amiss here to point out to the young seaside naturalist the most convenient and effective plan of keeping marine animals alive, for the purpose of daily observing their habits and investigating their history. The simplest apparatus for the purpose is that adopted by Mr. J. G. Price, of Woodside, near Liverpool, one of the most indefatigable and patient of our English observers. It consists of two large tin vessels capable of holding several gallons of water apiece, and a third of similar shape, but rather smaller, so as to fit into either of the former, having its bottom perforated with small holes, and

however, the skin of the *Holothuria* in many instances retains the character of the integument of an *Echinoderm*, and has imbedded in its leathern substance calcareous granules, or horny spines, which are evidently analogous to those of the *Echini*.

But a more striking feature of resemblance between the two races is found in the existence of locomotive ambulacral suckers, identical in structure with those of the Star-fish or Sea-urchin, wherewith the *Holothuria* is enabled to climb among the rocks, or to attach itself firmly to the surface of any submarine object. The suckers in question are variously disposed in different genera; thus, among the British species described by Professor Forbes, there are, in the great Sea-cucumber (*Cucumaria*), five rows of suckers disposed in pairs, which pass longitudinally from end to end of the creature's ovate body, forcibly reminding us of the disposition of the ambulacral orifices of the *Echinus*: and, besides these, a few others are irregularly dispersed over the surface of the body, similar to the former in structure and office, but disseminated in this manner

furnished with handles whereby to lift it. One of the larger vessels is filled with sea-water, and the smaller with the perforated bottom, wherein the living animals are contained, then placed gently in it. In order to change the water at the next tide, the second large vessel is filled with a fresh supply, and the smaller one with its contents removed into it. By this means the animals are disturbed as little as possible, they are not kept out of the water more than a few seconds, and the whole process gives scarcely any trouble. The inside of the tin vessels should be painted white.

for reasons connected with the changed character of the body in these animals, which, from the contractile nature of the integument, may assume the most diverse forms, and take the shape of a worm, a globe, or an hour-glass at pleasure.

In the Angular Sea-cucumber (*Cucumaria pentactes*), the body has a pentangular shape, and the rows of suckers run along the whole length of the prominent angles; while, in another genus, (*Psolus*,) the Snail Sea-cucumber, the suckers are all accumulated on a broad fleshy disc resembling the *foot* of a snail, so as to give the creature, when at rest, very much the appearance of a large *Slug*. But, whatever the situation of these suckers, their presence fully establishes the relationship between the *Holothuria* and the *Echinus*.

The mouth of the *Holothuria* is situated on one extremity of the body, and is a very curious and elaborate structure. Whilst the animal is at rest, it seems to be a mere orifice, into which food might be introduced; but, when in a state of activity, an apparatus of great beauty is unfolded, whereby the food is seized hold of and swallowed. This consists of a circle of beautifully branched tentacles, which are protruded and withdrawn at pleasure, and sometimes with considerable rapidity. When fully expanded, they present the appearance of some of the most elegant forms of *Actiniæ*, those living flowers described in a preceding chapter, and, like them, contract when touched; so close, indeed, is the resemblance, that in those *Holothuriæ* which bury their bodies in the ground, or encrust them-

selves with coral, sand, or other extraneous substances, as though for the purpose of disguise, the expanded tentacular apparatus might easily be mistaken for some species of Sea-anemonies.

Within the tentacular zone there is a circlet of calcareous plates, imbedded in a muscular ring, through which the food must pass; these are undoubtedly to act the part of teeth, and may be looked upon either as the last remains of the elaborate dental apparatus seen in the *Echinus*, or the first appearance of such teeth, as in the Leech and other *Worms* attain their full developement. To this succeeds a muscular gizzard, or stomachal cavity, and a long digestive tube, found always filled with sand or broken coral, out of which sufficient animal matter is obtained to afford nourishment to these apathetic creatures, which, however sparely fed they might appear to be, are stated to be used as food by the Chinese after the intestines have been extracted, the flesh boiled in sea-water, and then dried in smoke; indeed, it is said that the Malays carry on a considerable traffic in supplying the Chinese markets with dried "Trepang," as the edible *Holothuriæ* are called, thus forming an important addition to the fried earthworms, swallows' nests, and other luxuries, which grace a bill of fare in the Celestial Empire.

Misshapen and rude as a *Holothuria* looks to a person uninstructed as to its real construction and habits, to the Zoological student it is an object of very great interest in many points of view. Externally, it has every character of the Radiate type

of form, softened down and approximated to that of the Annulose type, to which we are now clearly approaching. In its internal structure, the same relationship to the Annulose division of Creation is clearly apparent, and in no circumstance more clearly so than in the bilateral condition of many of the internal viscera. A circulatory system exists similar to that of the *Echini;* but an important advance is here made in the provision of an apparatus for respiration of a most singular and beautiful description. In all the preceding families of *Echinodermata,* it was sufficient, for the purposes of respiration, to admit the salt water of the ocean freely into all parts of the interior of the body, so that every viscus might respire for itself, being constantly bathed with the aerated fluid; but here such a simple mode of proceeding is no longer permitted, and two organs are given for the purpose of conveying the external element into the body, and distributing it as largely as may be requisite, at the same time keeping it enclosed in proper channels. These organs consist of two tubes, which communicate with a cavity situated at the posterior extremity of the body, whereinto the water has free access. These tubes divide and subdivide into a most exquisite arborescent arrangement of canals, through all of which the respired fluid freely penetrates; while a most extensive system of blood-vessels, ramifying over the surface of the entire apparatus, brings the blood to be effectually aerated.

The offspring of the Holothuriadæ are still remarkably numerous. The eggs are formed in

several long blind tubes, hanging like the lashes of a many-lashed cat-o'-nine-tails from an orifice situated near the neck of the animal; and Sir John Graham Dalyell stated to the British Association met at Glasgow in 1840, that the young, when first produced, resembled small white maggots of the size of a barley-corn, and that he had known five thousand eggs to be laid by a single Holothuria in the course of a night.

But the most remarkable circumstances connected with the history of the Holothuriadæ relate to the astonishing power which they still possess, in common with other Zoophytes, of repairing mutilations that have been inflicted upon them, and of restoring lost parts of their bodies, to an extent that seems almost miraculous in creatures so highly organized. Among the plant-like forms of the humbler polyps it was comparatively without much surprise that we witnessed the reproduction of branches that had been lopped off, or the replacement of lost tentacula; and, even in the Star-fishes, the budding forth and regeneration of lost rays was to a certain extent intelligible, when we reflected upon the nature of the living cortical crust, whereby the different portions of the ray were formed and secreted: but we are here treating of creatures which exhibit an organization of such delicacy and complexity, that it would seem as absurd to imagine the possibility of the creature's existing without its full complement of parts, as to expect a man to live without his heart or his stomach, much more to entertain an idea of the possibility

of such vital organs growing again after they have been once removed.

Nothing, however, is more true than that such extraordinary capabilities have been conferred upon the animals we are now considering. If irritated or alarmed, they will, as though out of pure spite to the anxious naturalist who has succeeded in capturing them, without the slightest remorse or compunction burst themselves by the violent contortions of their body, and, like so many Catos, insanely discharge all their viscera, rather than be taken whole; so that some species are rarely obtainable in a perfect condition. But the most wonderful part of the tale is, that a catastrophe, so grievous to the spectator who witnesses such a tragedy, seems to be of very small importance to the actor, as the creatures seem able to get on just as well without any bowels, as when possessed of such trifling additions to their economy; and, what is more, can reproduce them in a most convenient manner, so as again to become furnished with a complete set. Neither are they at all particular as to what parts of themselves they thus summarily dismiss from their service. Sir J. G. Dalyell has observed them dispense with the flower-like tentacles that surround the mouth, with their mouth itself, with their circlet of teeth and gullet, as well as the internal viscera, "leaving the body an empty sac behind." Yet it does not perish: all the lost parts are regenerated within the space of three or four months, and the animal assumes its pristine condition. The same eminent observer states that

"some species of Holothuria divide spontaneously through the middle into two or more parts, which become ultimately perfect by the developement of new organs."

The Holothuriadæ have been distinguished by the name of cirrho-vermigrade Echinodermata; because, although they possess the cirrhi, or suckers, of the Star-fishes and Echini, they can likewise progress after the manner of worms by the lengthening and contracting of their soft and flexible bodies. In the next group which we have to study, the worm-like form is fully established, and the suckers are entirely dispensed with. The reader, who has followed us thus far, will therefore perceive that we are arrived upon the confines of the group of Echinoderm animals, and are about to enter upon a new domain of Nature, to lose sight of the *Radiated* type of structure which has so long characterized the races of animals that have come under our consideration, and to find henceforth the animals that will present themselves constructed upon a new and perfectly different plan.

The Siponculidæ (fig. 86. *h.* and fig. 95) might, from their external appearance, easily pass for real worms; and even in their habits they conform so closely with those of many Annelides, that nothing short of strict anatomical comparison would enable the naturalist to withhold them from the catalogue of those animals. No traces are now left of the quinary division of the body, which formed so remarkable a feature in the structure of all the Echinoderms we have as yet described; even the tentacula that

Fig. 95.

surrounded the mouth of the Holothuria are reduced to a rudimentary condition, or, more generally, quite obliterated. The body of the Siponculus is so long and flexible, and, moreover, its muscular envelope so strong and precise in its movements, that locomotive suckers are no longer needed, as all the movements of a worm can now be completely effected; and even the only vestiges of a spinous skin are found in the horny setæ, or bristles, resembling those of worms, with which some species are furnished.

Their mode of life is various: some bury their bodies in holes, which they bore to a considerable depth in the sand, lining them throughout with a calcareous mortar that exudes from the external surface of their bodies. From the mouths of these holes they protrude a long retractile proboscis, furnished at its extremity with rudimentary tentacula, wherewith they fish for such food as they require. Others live under stones, or lurk in the crevices of rocks; while one remarkable species (*Siponculus Bernhardus*, Forbes,) adopts the manners of the Hermit Crab, and lives in the shells of periwinkles and other small univalve shells. This Siponculus, says Professor Forbes,* "would appear, however, to be of a less changeable disposition both of mind and

* Hist. of British Star-fishes, p. 252.

body than its Crustacean analogue; and, when once securely housed in a shell, to make that its permanent habitation. Whether the egg is originally deposited in the future abode of the animal by some wonderful instinct, or is only developed when lodged by the waters in such a locality, or whether the parent Siponculus bequeaths the chosen lodging of its caudal termination to its eldest-born, and so on from generation to generation, a veritable *entailed* property, we know not at present; but the inquiry is a most interesting one, and well worth the attention of the experimental Zoologist. The Siponculus is not, however, content with the habitation built for it by its Molluscan predecessor; it exercises its own architectural ingenuity, and secures the entrance to its hole by a plaster-work of sand, leaving a round hole in the centre sufficiently large to admit of the protrusion of its trunk, which it sends out to a considerable length, and moves about in all directions with great facility."*

Having now fairly arrived at annulose forms of existences, we might at once introduce the reader to the third sub-kingdom of Animated Nature; but, before doing so, we have thought it best to describe, more generally than we have yet had an opportunity of doing, the phenomena connected with developement and growth, as witnessed in the two great groups of living beings treated of in the preceding pages; and to this subject we shall therefore devote a special chapter.

* A detailed account of the internal structure of the Echinodermata will be found in the Author's "General Outline of the Animal Kingdom."

CHAPTER XIV.

ON THE DEVELOPEMENT AND METAMORPHOSES OF THE ACRITE AND NEMATONEUROSE CLASSES OF ANIMALS.

We are all of us in the habit of contemplating the different races of animals with which we are acquainted as constantly possessing the same form, and exercising similar attributes, throughout the whole period of their existence; and if we allow with our immortal bard that "every man in his time plays many parts, his acts being seven ages," still we recognize in the child, the boy, and the man, the same being exhibiting various degrees of size, strength, and intellect: nothing can however be more erroneous than such a circumscribed notion.

Every animal, during the progress of its life, plays the parts of many different animals; and that under such diversified forms, that at successive periods of its existence it cannot in strictness be regarded as the same creature. Moreover, the offices and duties assigned to it during the phases of its progressive developement are so various frequently, so opposite, that its external and internal organs become totally changed, in conformity with varying functions as-

signed to them, so that every living being is, in fact, a succession of perfectly distinct animals growing one out of the other. We doubt not that such an assertion as this may be rather startling to many of our readers; nevertheless, we doubt not that a little reflection will fully establish the truth of the doctrine.

The frog goes through the usual gradations of growth as to size, and we have young frogs, middle-aged frogs, and old frogs, all exhibiting precisely the same form, and possessed of similar instincts; yet this very frog was formerly a fish, a tadpole, living in the water, breathing by means of gills, and sculling itself through the water by means of a long tail, without limbs, or any indication of its future destiny; moreover, the tadpole was previously an egg, having very little appearance of ever being promoted beyond that condition.

We all allow that a caterpillar is an animal: yet who would dream, did not every-day experience attest the fact, that the caterpillar would soon live under the form of a chrysalis; and the chrysalis in turn burst forth a gaily painted butterfly? or who, ignorant of the fact as taught by experience, could venture to assert that the chrysalis and the butterfly were one and the same creature?

The above are examples of the great truth we are now about to investigate, familiar to every one; not so others, equally astonishing, that we shall hereafter have to lay before the reader: and it would be no easy task adequately to explain how such changes are brought about, did we not begin at

the very beginning of our subject, and, by explaining the simplest instances of developement as they occur in the lowest members of the animal creation, prepare the way for more abstruse and complicated inquiries, that will present themselves in future chapters.

The truth is, that all the higher animals are at the first period of their existence almost in the same condition which the very lowest races permanently maintain; and we are, therefore, compelled to take a brief retrospect, in order to introduce a series of miracles which we must now prepare to contemplate.

Perhaps no fact is more a matter of every-day observation than this,—that all animals and plants *grow;* that is, that they increase daily in size as they advance from their earliest condition, until they arrive at the full and mature dimensions assigned to them by Nature. The mushroom, in the course of a single night, swells from a germ, almost imperceptible from its minuteness, to a plant weighing two or three ounces. The sapling which springs from the acorn, increasing year by year in all directions, spreads at length its giant arms so wide, and rears its head so high, that it becomes the monarch of the forest. Have any of my readers ever thought how this can be accomplished, or in what the *growth* of plants and animals essentially consists? Buffon, with that boldness of speculation for which his writings are so remarkable, first hazarded a theory upon this subject, which his contemporaries regarded as one of the wildest and most visionary of all the fanciful ideas which emanated from the fertile brain

of that imaginative naturalist. No sooner had the microscope displayed to the admiring world the innumerable living atoms that crowd the drops of putrid water, than Buffon declared his belief that these were the elementary particles of which all living beings, both animals and vegetables, were formed; or, in other words, that all organized beings were but an assemblage of *monads* built up into the form of the creature which is thus constituted: an assertion which, in those days, procured for its author no little obloquy and harsh criticism; while, strange to say, the accurate observations and strictly philosophical deductions of modern physiologists have only served to shew that the theory of the French naturalist was essentially correct, although, unfortunately, too much in advance of the times in which it was promulgated to permit its truth to be recognised.

A mineral only increases in size by the aggregation of similar particles accumulated upon its exterior; and, however regularly and symmetrically these particles may be arranged, as, for example, in the construction of crystals of definite forms, the whole progress of growth is strictly under the direction of physical agents: but the growth of a plant, or of an animal, is a vital process of a totally different character; all additions in size being made in the interior of the living substance, by the agency of that substance itself, in a manner which we will now try to explain.

If the reader will turn for a moment to the representations of the simplest confervoid Infusoria,

delineated in a preceding chapter, (figs. 31, 32, 33, 34, &c.,) it will at once be perceived that the growth of these compound beings is accomplished by the constant division of each precedingly existing portion into two or more parts, precisely resembling each other. The *Gaillonella*, for example, (fig. 32, *d*,) is, when magnified, as represented in the same figure at *e*, seen to be made up of a series of little cells placed end to end like a string of beads; and these cells have obviously all sprouted from each other, each, on attaining its full dimensions, giving off a young cell in every respect resembling itself, or dividing into two precisely similar to each other, as in the fissiparous reproduction of the higher animalcules; and, by this simple process being repeated again and again, the enlargement of these compound animalcules is accomplished, every cell being a repetition of the last, and endowed with similar powers of nourishing itself, and of producing a new cell in its turn. Even when severed from the rest, it may still retain the same capability of existence which it had when conjoined with the rest; and may thus become the parent stock of a future progeny of cells, or, in other words, of a new *Gaillonella*. Who, then, in this case can deny that each individual cell is a living creature; seeing that it can both nourish itself and reproduce itself, exhibiting thus the two great functions which characterize organized beings?

But, to carry out this argument a little further, let us select another familiar illustration, derived from the vegetable kingdom. Every one knows how rapidly the *puff-balls* in our meadows are developed,

growing during the course of a single night to a size that would be perfectly incredible, did not ordinary observation teach us the reality of the fact; and yet to the simple question, "By what means is this extraordinary increase effected?" it has been quite impossible, until very recently, to give anything like a satisfactory reply. On cutting into these living masses, they are found to be quite homogeneous in their texture; the internal part consisting entirely of a spongy substance, without any vessels for the circulation of nutriment, or other complication of structure. When examined, however, with high magnifying powers, every portion of the spongy mass is seen to consist of microscopic cells, which, exactly as in the case of the Gaillonella, are perpetually springing from each other, every cell producing a new cell precisely similar to itself as soon as its own growth is accomplished; so that in this way millions of millions of these vegetable cells are developed in the course of a very few hours, and by their prodigious accumulation build up a *puff-ball* measuring a foot in diameter. Now, it is evidently quite impossible to deny that every one of these countless cells is as much alive as the whole mass of which it forms so apparently insignificant a part; and if the power of nourishing itself, and of reproducing its own likeness, be any proofs of individuality, every cell is as much alive as the monads, (fig. 38, *a*,) which swim at large in the putrescent water wherein animal or vegetable substances are decomposing.

But we must go a step further in order to discover

all the important deductions that may be drawn from the facts connected with these primary cells, of which the humblest vegetables and animals are entirely made up. Each cell, once formed, possesses an independent power of germination, *even when separated from the rest of the organism*, of which it originally formed but an integrant particle; and even when dried into an imperceptible atom, and blown about as dust before the wind, these myriads of invisible germs continue to retain their vitality, and only wait for accident to place them under favourable circumstances, by supplying moisture, soil, and warmth, again to sprout and multiply themselves, till every one gives birth to countless millions of cells, and becomes in this way parent to a progeny whose aggregate constructs another plant like the original, from which the parent cell was formed.

Such being the means whereby the growth of the most simple vegetables is effected, and the provision made for ensuring their dissemination, it becomes at once apparent that the theory of Buffon relative to the composition is essentially correct; each atom of the substance of such plants being endowed with independent life, it is of no matter how small, how inappreciable by our senses, the individual dried cells may be: the germs of such vegetables as these may, for aught we know, float continually around us in the atmosphere under dimensions of inexpressible minuteness, and find their way through substances which are usually thought impervious; as, for example, in the case of a mouldy egg, the reproductive germs have evidently made their way

through the pores of the egg-shell, with as much facility as a bird flies through the grated bars of a dungeon-window. Even in the animal kingdom the dissemination of the Infusorial animalcules can only be accounted for upon the same principle: the seeds of life, being everywhere diffused throughout the atmosphere, are instantly at hand to fill each vacant spot in which their growth can be permitted; nay, the very dust abounds with vital particles ready to start into active existence whenever opportunity occurs.

In the more highly organized animals and plants, it is, however, necessary that such wholesale reproduction should be very materially circumscribed; and that, instead of every cell which enters into the composition of the body being endowed with a power of generating an organism resembling the entire being from which it originated, such power of germination should be limited to a comparatively small number: hence the necessity for providing *seeds*, *gemmules*, and *eggs*, which are, in reality, nothing more than cases wherein a few germinating cells are carefully stored up and nourished during the earlier periods of their developement. The separation of plants and the humbler Zoophytes into any number of fragments only multiplies them to a corresponding extent,—as a whole forest might be raised from the cuttings of a single tree; but it would be rather too prolific an addition to the human population of this world, if, when on the battle-field the shot and shells tear regiments into tatters, every fraction of each slaughtered soldier

should, like the teeth of the fabled dragon, grow into a perfect man.

Various means have, therefore, been adopted to prevent such dangerous fertility, and yet ensure an adequate supply of germinating cells adapted to the case of every race of animals: the ciliated gemmules of the sponge (fig. 6), the buds that form the *Hydra* (fig. 11), the germs that sprout upon the filaments of *Tubipora* (fig. 24, 3), or are reared within the horny cups of *Sertularia* (fig. 27), or grow within the egg-producing membranes of *Actinia* (fig. 30, *g*, *h*), are only different aspects under which these wondrous cells become developed under circumstances which restrict their growth to parts adapted to produce and cherish them.

Nature afterwards adopts a higher type; and tubes, or little bags, are placed within the body, in which alone the eggs are formed. In the *Asterias* these are very numerous, as we have seen already; but in *Echinus* all these tubes become reduced to five capacious sacs, wherein the *ova* are constructed and retained till ready for expulsion. These sacs, called the *ovaria*, at certain periods are distended with prodigious numbers of such simple eggs, adapted by their multitudes to store the ocean with food on which higher forms of life may be nourished.

We shall now be able to understand the process whereby growth and developement are accomplished throughout the Acrite classes of animals. The gemmule of the sponge (fig. 6) is nothing but a minute packet of germinating cells detached from the mass of the parent, and provided with lo-

comotive cilia to row it about from one place to another. In this condition, the reader will at once perceive that it is in all respects strictly comparable to an Infusorial animalcule; neither would any one unacquainted with its subsequent history ever think of refusing it a place among the animals composing that class of beings. No sooner does the animalcule sponge, however, settle down upon the rock where it selects its residence,—or, perhaps we ought rather to say, is accidentally thrown, — than the individual cells composing it immediately begin to divide, and divide again, by spontaneous growth, multiplying themselves from tens to hundreds, from hundreds to thousands, and from thousands to millions, until the spreading mass attains the size allowed to it by nature. Every microscopic cell, therefore, may here be looked upon as acting independently, although co-operating with all the rest in the formation of the required structure.

But, wonderful and inscrutable as is this power of self-multiplication bestowed upon the primary cells of which the mass consists, it constitutes but a small part of the process that is going on within the growing fabric. These cells are the only visible agents employed in the construction of the skeleton that props and gives stability to the otherwise soft and shapeless living substance of the sponge: secreting from the element around them particles of horn, or flint, or stone, they build them up into the various kinds of skeleton we have before described, nor is an atom out of place through all the growing mass; and thus the grand result

attains the definite specific form peculiar to the animal.

Yet, after all the physiologist has thus succeeded in detecting, labouring hard, and straining all the powers of optical research, he but perceives the bricks and mortar Nature has contrived wherewith to build her edifices—the rude materials employed in forming living beings; nothing more. He feels with awe how great, how unimaginable, that Power must be, who on such atoms has imposed those laws, that it will be for ever far beyond all human penetration to explore.

It will be seen, from what has been said above, that we must regard all growth as proceeding from the multiplication of the germinating cells of which an animal is composed; and of course the shape and condition under which an animal exists will be in accordance with the arrangement of the aggregate of those cells at any given period of its existence. This simple fact, which is incontrovertible, is the basis upon which all the phenomena of METAMORPHOSIS depend; as will be evident from the following example of the metamorphoses which the Acalephæ, similar to that represented at fig. 63, undergo. These creatures, in fact, pass through the conditions both of Infusorial animalcules and Polyps before they arrive at their mature form, assuming in turn the habits and appearance of each of these dissimilar classes. The young Acaleph at its first appearance resembles precisely the ciliated gemmule of a sponge, consisting entirely of a minute, pear-shaped mass of cells, which is

rowed about in the water by innumerable cilia scattered over its surface; in this condition it is to all intents and purposes an animalcule. At a slightly more advanced period of its growth the pear-shaped body assumes the form of a bell, from the open mouth of which little tentacles become developed, whilst all the cilia are obliterated, giving the animal exactly the appearance of a Hydra, or of a *bonâ-fide* Polyp. The gelatinous disc then begins to extend itself; and, after various gradations of developement, assumes the condition of the adult Acaleph, and completes its career.

The last subject that will require our attention in this place is the nature of the egg of the lowest of the oviparous races of animals, and the manner in which the young are developed in *ova* of the simplest structure; a knowledge of which will considerably facilitate our explorations when we come to speak of animals higher in the scale of creation.

An egg of this description, before the embryo begins to be developed, consists of a *yolk*, of a delicate transparent globule of microscopic dimensions containing fluid, enclosed in the yolk, called the *germinal vesicle*, and of a thin covering or shell enclosing these essential parts. Such is the "crude original" of by far the great majority of animal existences! A few subordinate structures are afterwards added to these; but essentially, all oviparous animals, whatever may be their subsequent form, however different their attributes, worm, insect, snail, fish, reptile, bird, all are developed from an *egg* of similar composition! Perhaps, there is no

subject of reflection more overwhelming to the mind than this simple fact, that the yolk of an egg with the translucent spot within it, isolated and cut off from all external influences, should be endowed with powers so mysterious, so incomprehensible.

Let us, however, now take an egg of one of the humblest worms,—such, for example, as that represented in fig. 60,—in order to estimate the changes that take place in it during the growth of the little Entozoon it produces.

The yolk at first appears a single mass of granular substance filling the egg-shell: after a time, however, a very strange process is observable; the yolk becomes indented across by a deep fissure, and soon divides into two distinct halves; each half separates into two others, and these again split, each of them into two more; so that in a very short period the yolk is broken up by this repeated division into an immense number of little cells, the materials wherewith to build the future worm. After some time longer the cells thus formed seem to be agglomerating themselves into a definite shape, the nature of which soon becomes apparent; and a worm-like form, folded upon itself and curiously moulded to the capacity of the shell, becomes distinctly recognisable. The worm, be it remembered, is at this time entirely composed of these approximated cells, without any internal cavity or defined organs; and this, in fact, is the condition in which many of the Sterelmintha remain through the whole period of their existence. No effort is as yet made to de-

velope even a rudiment of an external limb, neither are organs of sensation of any sort as yet hinted at. The Sterelminthous worm, when arrived at maturity, is, in fact, precisely in the same condition that the grub or larva of an insect exhibits transitorily before the senses and external appendages of the body begin to shew themselves.

The further prosecution of this enquiry we shall resume in its proper place; the preceding remarks will, however, be of importance when we come to discuss more fully the phenomena which accompany the developement of the articulate classes of animals, and the metamorphoses to which they are subject: for let it be understood, that although for the convenience of the Zoologist it has been found necessary to divide and subdivide the animal kingdom into Sub-kingdoms, and Classes, and Orders, and Genera, and doubtless the members belonging to each are widely separated from each other by many and most obvious distinctions, we shall nevertheless continually perceive, as we thus closely investigate Nature, that the same grand laws preside throughout the entire series of animal organisms; proving that a unity of design pervades all the works of the ALMIGHTY CREATOR; and that, innumerable and diversified as are HIS creatures, "all are but parts of one stupendous whole," collectively proclaiming, in language not to be misunderstood, the power, the wisdom, the beneficence of GOD.

CHAPTER XV.

ARTICULATA.

ANNELIDA.

The Annulose or articulated division of the animal creation, upon the contemplation of which we are now about to enter, comprises all those races of living beings which, like the Earth-worm, the Fly, the Scorpion, or the Lobster, have their bodies composed of a succession of rings or annulose segments, to which external appendages, given for the purpose of locomotion, are generally superadded; these latter being always symmetrically arranged upon the two sides of the creature. Infinitely diversified in form and attributes, the Articulata are dispersed through every region of our globe. The wide realms of the ocean are densely occupied by innumerable forms of animals of this description; the fresh waters of our lakes and streams, of every pond and every ditch, abound with countless multitudes. The soil of the earth harbours its fair proportion; while almost every kind of vegetable, each shrub, each tree, nay, almost every flower and every leaf, affords a residence to some appropriate inhabitant belonging to this extensive department of creation. Lastly, the air itself gives ample range for insects capable of flight

to execute important duties in that element, and thus secure a new field for activity and life.

Dissimilar, but yet allied in structure to each other, the animals composing the articulated division of nature have been arranged in several classes, easily distinguishable by simple and prominent characters.

The ANNELIDANS, the feeblest and the humblest members of the group, have their bodies formed of very numerous little rings, (*annelli*, whence the name,) to each side of which there are frequently connected organs of different kinds, which are either useful as agents in effecting locomotion, or are devoted to some special purpose; although to many of the lower races such limbs have been altogether denied. The movements of these worm-like animals are still very sluggish, and their senses obtuse; in the lowest members of the group, indeed, the instruments of the higher senses are not more apparent than in the Holothuria and Siponculus, to which in very many points of their economy they are intimately related. Yet, apathetic as such humble creatures appear, and despised and neglected as they generally are, we shall soon perceive, as we become acquainted with their history, that they are by no means unworthy of careful examination; many of them displaying singular perfection of internal structure, and all an adaptation to the particular situations they are intended to occupy, which must forcibly interest the attention of any reflecting mind.

But it is not in this point of view only that the Annelidans claim our attention; a very slight acquaintance with their history will serve to teach us that

they are really of very great importance in the general scheme of creation, and that upon them numerous races of animals are almost entirely dependent for their subsistence.

> "From Nature's chain whatever link we strike,
> Tenth or ten thousandth, breaks the chain alike—"

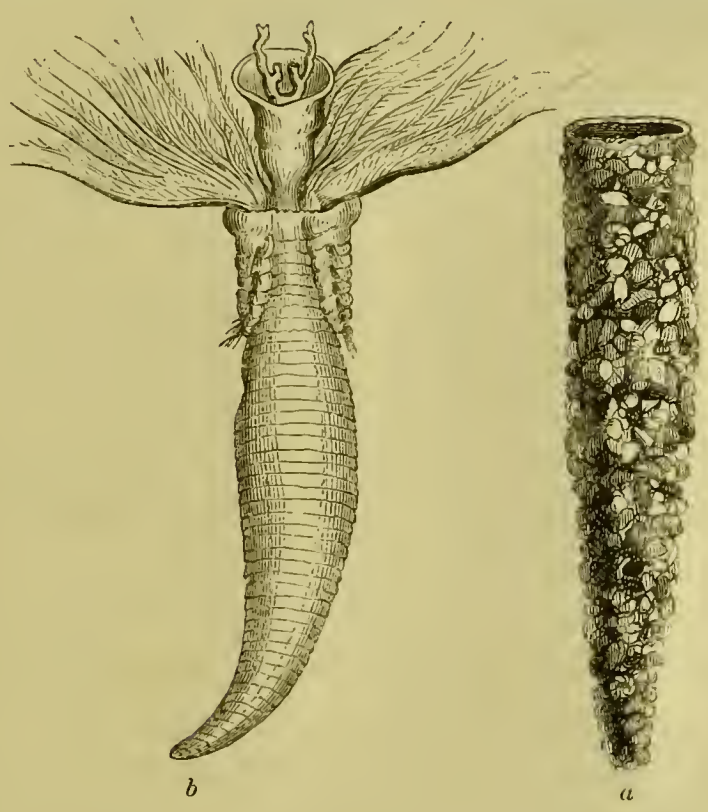
and so numerous are the mutual dependences which concatenate all the various tribes of living beings, that there is no possibility of calculating how extensively the absence of any one group might influence the well-being, or even the existence, of others. The herbivorous and graminivorous species even of quadrupeds, by converting the grass of the fields into their own flesh, prepare food which is indispensable to enable the more intelligent carnivorous animals of the same class to live; and, in a lower sphere, the worms we are now about to speak of, are, in like manner, constantly employed in changing the meanest and apparently most useless remnants of nutritious matter into animal food, such as is an essential provision for the maintenance of innumerable beings far more highly gifted as relates to their faculties and the amount of enjoyment of which they are capable.

The lowest members of the class before us exhibit, in many respects, habits analogous to the vermiform Echinodermata. Most of them are marine, living in the vicinity of the shore, where they burrow in the sand, much in the same manner as the Siponculi; and, in many instances, they are found to line the holes in which they live with a calcareous deposit exuded from the surface of their bodies; or some of them con-

struct factitious tubes of foreign substances, or even residences composed of true shell.

Among the tubicolous, or sedentary Annelides, we shall select a few of those most frequently met with on our own shores, in order to illustrate their habits and general economy. Every one must have observed that stones, dead shells, fragments of pottery, or any similar substances that have been immersed for any length of time in the sea, become covered over with irregularly twisted calcareous tubes, which some-

Fig. 96.



times accumulate in great abundance, and not unfrequently masses of similar tubes are brought up from considerable depths by the lines of the fisherman. If, while the contained animals are alive, these

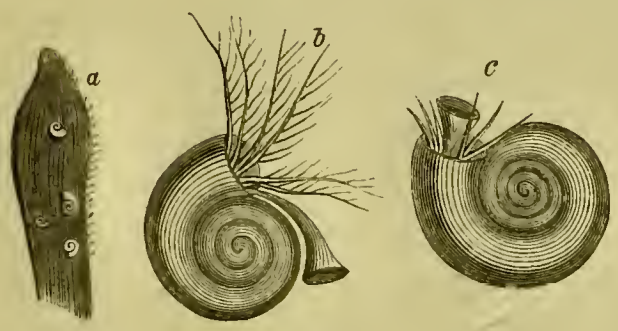
be placed in a vessel of sea-water, few spectacles can be more pleasing than that which they will speedily exhibit. The mouth of the tube is first seen to open by the raising of an exquisitely constructed door, and then the creature cautiously protrudes the anterior part of its body, spreading out at the same time two gorgeous fan-like expansions of a rich scarlet or purple colour, which float elegantly in the surrounding water, and serve as branchial, or breathing-organs. The *Serpula*, for such is the name of the worms which fabricate these tubes, when withdrawn from its residence (*fig.* 96, *b*) is seen to have the hinder part of its body composed of a series of flattened rings, entirely destitute of limbs or any other appendages. The tube wherein this Annelide resides is calcareous, being formed by an exudation from the creature's body, which, even under water, soon hardens into shell, by a process very similar to that whereby the shells of the Mollusca are constructed, and, in this tenement, the limbless worm is necessarily destined to remain during its whole life-time fishing for such food as may be obtained in the immediate vicinity of its residence.

The *Spirorbis* is another shell constructed by minute Annelidans, still more common than the preceding; for upon the beach it is scarcely possible to pick up a piece of sea-weed without finding it studded over with numerous specimens, as represented in the annexed wood-cut (*fig.* 97, *a*). The shelly tubes inhabited by these little worms are not like those of Serpula, of an irregular twisted figure, but, on the contrary, are rolled upon themselves in a spiral form,

with one of the flat sides firmly cemented to the surface of the object to which the creature attaches itself.

When magnified (*fig.* 97 *b. c*) the neck of the Spirorbis is found to be furnished with a perfect

Fig. 97.



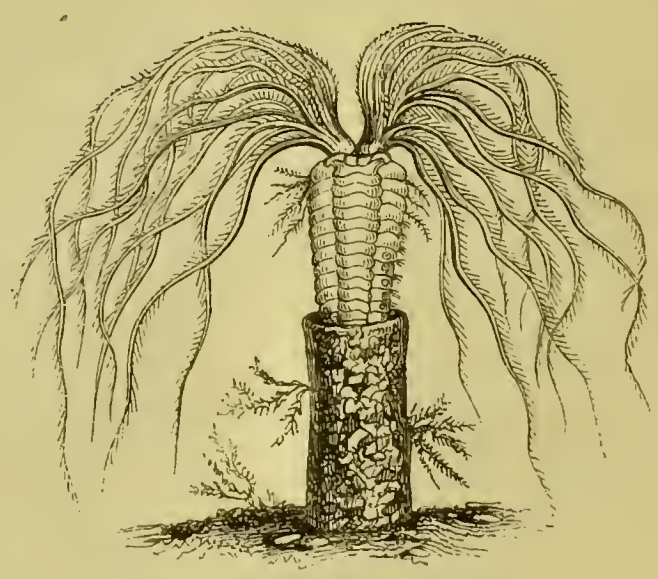
operculum, formed as in Serpula, by a peculiar developement of one of the tentacula in the vicinity of the mouth, which answers the purpose of a little door, and likewise with branchial plumes of a less complicated structure than in the genus last mentioned, but still presenting a very extensive surface for the purpose of exposing the blood which passes through them to the influences of the oxygen contained in the surrounding water.

A little reflection will at once shew us why the respiratory apparatus of these tube-inhabiting worms is situated in so strange a position, being invariably attached to the neck of the animal, and not as in all other races of the Annelida distributed in various parts of the body. Had the breathing surfaces been placed in any other situation, it is evident that, while the worm remained in its shell, the water could never have obtained free admission to them, and

consequently respiration would have been impossible; whereas, by the elegant arrangement adopted, the simple raising of the operculum, which closes the orifice of the shell like a lid, or the slightest protrusion of the creature's head, suffices to ensure the due aeration of the blood, without unnecessarily exposing the little worm to danger.

The above mentioned annelidans reside in a calcareous tube, which is secreted by the surface of the animals, and hardens into real shell. There are, however, upon our shores numerous species which inhabit factitious residences, made of grains of sand or fragments of shell, that they are enabled to construct for themselves by means of a remarkable set of organs provided for the purpose. The worms in

Fig. 98.



question are called *Terebellæ,* a name originally bestowed from an erroneous notion entertained by the ancients, that they were able to bore into solid stones, a mistake, the origin of which it will be easy to

understand when we have explained the real nature of their curious domiciles.

The body of the *Terebella* (fig. 98) resembles in its general aspect that of a Serpula, and in like manner the breathing apparatus is attached to the creature's neck; but here it will be observed the branchial organs consist of little arborescent tufts, and not of fan-like expansions as in the preceding genera.

Instead of having the little operculum of the *Serpula* and *Spirorbis*, we find the head in this genus surmounted by numerous fleshy filamentous appendages, of very considerable length, and moreover endowed with extraordinary powers of extension and contraction, whereby they can stretch themselves to an amazing length, or shrink into a very small compass at pleasure. Each of these filaments is imbued with a glutinous secretion, which adheres tenaciously to anything it touches, and thus to a certain extent becomes a prehensile organ.

Thus provided the Terebella is quite ready to set about the construction of its residence, which it accomplishes in the following manner,—Stretching out its tentacula in all directions upon the sand in search of proper materials, it speedily selects such fragments as are adapted to its purpose, which become attached particle by particle to the glutinous surface of the retractile filaments, and are thus brought down to the neck of the animal where the formation of the shell begins. Here they are arranged with as much regularity as rows of bricks in the construction of a house, and cemented together by the tenacious exudation, until a tube is formed,

encasing the upper part of the creature's body, and which is progressively extended by the same process until it attains the length of several inches. By keeping the animals alive, the whole process may easily be witnessed, and by varying the materials within reach of the tentacula the Terebella can be made to convert its tube into a kind of party-coloured Mosaic-work at the pleasure of the observer.

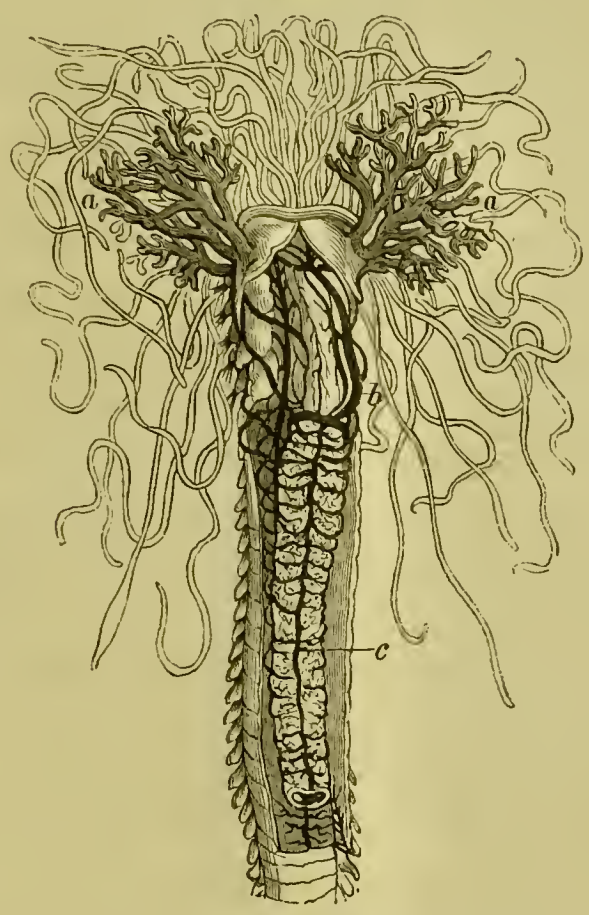
When much annoyed the *Terebella* seems to have no objection to leave the shell which it has thus constructed with so much labour, and to set out in search of another locality; and sometimes it may even be met with in considerable numbers at very low tides lurking beneath the stones close to the water's edge. Its mode of locomotion is peculiar, —stretching out its long and very extensible labial tentacles, they are easily fixed by their own adhesive power to any foreign bodies in the vicinity, and then, by the assistance of these numerous living ropes the creature drags itself along from place to place, of course continually shifting its hold as it wishes to proceed further. In the water, moreover, they are stated to be able to swim something after the manner of a leech, by the undulatory movements of their bodies.

We must now proceed to examine the internal economy of these tubicolous worms.

The circulation of the blood is effected in the following manner,—Placed beneath the integument of the back, and lying immediately upon the commencement of the alimentary canal, is a capacious vessel (fig. 99 *c*), which, by its powerful and regular

contractions, is soon seen to perform the functions of a heart. Into this vessel all the blood, and most probably the nutriment derived from the alimentary

Fig. 99.



canal, as well as the blood from all parts of the body which has been deteriorated by circulation, is conveyed by large veins, which open into its posterior extremity. From the opposite end of the heart are given off numerous vessels which run immediately to the respiratory tufts, *a*, *a*, that are situated on each side of the neck, and distribute the blood through all the branches into which those organs subdivide. Here, being exposed to the in-

fluence of the air contained in the surrounding element, the blood becomes arterialised, and is again collected for distribution through the body. This is accomplished by a large vessel, which receives the blood from the branchiæ, and as it runs along the ventral aspect of the body gives off branches right and left, which divide and subdivide to supply the whole system with the vital fluid.*

The anatomical reader will therefore at once perceive that the ventral vessel and its branches perform the functions of the arterial system, and that the branchiæ themselves here act the part of a heart. Indeed, according to Milne Edwards, the branchial fringes contract from time to time very forcibly, and thus drive the blood after it has undergone respiration into the vessels appointed to distribute it through the body. Consequently, it will be seen that there are two motive agents here employed in order to complete the circulation, one, the contractile vessel *b*, destined to supply venous blood to the branchial tufts, while the branchiæ act the part of a heart to the rest of the system.

A second important group of the *Annelida* is represented by the well-known Medicinal Leech, and consists of a race of worms at once distinguishable from all others by the terminal suckers appended to the two extremities of the body, which here supersede all the ordinary instruments of locomotion, and have obtained for the whole tribe the appellation of "SUCTORIAL ANNELIDES." The general characters of the Leech are too well known to require

* Milne Edwards. Annales des Sciences Naturelles, tom. x.

description here. Their long and flexible body, by the undulating movements of which they can swim gracefully through the water in which they live, as well as their other mode of progression, by alternately fixing their sucking-discs to the surface of aquatic plants or other objects upon which they move, are familiar to every one, although, perhaps, few are aware how numerous and widely distributed worms of this description are.

They are by no means confined to fresh water: many species are marine, living upon different races of fishes to which they attach themselves, leading a parasitical life at the expense of their unfortunate victims. Others persecute the finny inhabitants of our ponds and rivers, or, even leaving the waters, come on shore in search of food, where they take up their abode in damp or humid situations, and sometimes become serious annoyances to the traveller. Of these terrestrial Leeches, perhaps, the most formidable are those which frequent the woods and swampy grounds of the Island of Ceylon, where they are always ready to fasten on unfortunate travellers; and, from their activity and bloodthirstiness, are such formidable assailants as to render the places that they occupy almost impassable.

The structure of a Leech is evidently widely changed from that of the *Tubicolous Annelidans*, and their respiratory organs are found to be constructed upon principles adapted to their altered habits. The branchial tufts, situated upon the neck of the sedentary worms described above, are now replaced by a totally different apparatus, which,

is equally efficient for the purposes of the animal. This consists of a series of pores, arranged along the sides of the Leech's body, each leading into a little membranous bag, situated in the interior of the Leech, which is, of course, filled with the surrounding element. These numerous bags are, essentially, internal branchiæ; and the blood, which is largely distributed over them by a beautiful net-work of vessels, is purified exactly in the same manner as when the branchiæ are external.

The most interesting part of the anatomy of the Leech relates, however, to the structure of its mouth, which presents a piece of mechanism that is quite unique in the Animal Creation. In the medicinal Leech, which alone possesses the apparatus we are about to describe in a complete condition, the mouth is a dilatable orifice, situated near the centre of the anterior sucker, and would seem, at first sight, to be but a simple hole. Just within the margin of the aperture, are situated three beautiful little semicircular horny saws, arranged in a tri-radiate manner, so that their edges meet in the centre. It is by means of these saws that the Leech makes the incisions whence blood is to be procured, an operation that is performed in the following manner: no sooner is the sucker firmly fixed to the skin, than the mouth becomes slightly everted, and the edges of the saws thus made to press upon the tense integument, a sawing movement being at the same time given to each, whereby it is made gradually to pierce the surface, and cut its way to the sluices of blood

beneath. Nothing could be more admirably adapted to secure the end in view than the shape of the wound thus inflicted, the lips of which must necessarily be drawn asunder by the very contractility of the skin itself; nor can we doubt that the enormous sacculated stomach, which fills nearly the whole body of the Leech, is equally a contrivance to render these creatures efficient as medicinal agents for the use of mankind. That it was for man, and not for the Leech, that this structure was designed, there can be no reasonable question. The Leech, in its native element, could hardly hope for a supply of hot blood as food; and on the other hand, its habits are most abstemious, and it may be kept alive and healthy for years, with no other apparent nourishment than what is derived from pure water frequently changed; even when at large, minute aquatic insects and larvæ form its usual diet: whence, then, the necessity for this curious cupping apparatus?

Another convincing proof of the adaptation of the economy of these Leeches to the necessities of mankind, rather than to their own support, is the remarkable disproportion between the quantity of blood swallowed at a meal, and the slowness of its appropriation as nutriment. A Leech, in the course of half an hour, will gorge itself almost to bursting; while observation proves that it requires a whole year to digest the quantity of food thus rapidly imbibed, during the whole of which time the blood remains in the body of the Leech in a fluid condition, instead of coagulating or becoming putrid,

as it would inevitably do under any other circumstances.

The medicinal Leech is found in great abundance in Russia, Sweden, Norway, Hungary, and Bohemia, and likewise throughout Germany, Holland, Italy, and Spain. In France, they are by no means so abundant; and in England, we are almost entirely dependant upon the importation of Leeches for our supply. Such, indeed, is their utility in medicine, that they form a very important branch of commerce, as will be pretty evident when we are told that, according to a statistical report published in 1826, the hospitals of Paris alone consume upwards of three hundred thousand per annum.

With respect to the other Leeches commonly met with in the streams and rivulets of our own country, various and most contradictory opinions have been entertained as to their capabilities of phlebotomizing other animals. Linnæus asserts of the Horse-leech (*Hirudo sanguisuga*), that nine could kill a horse! whilst others maintain that this redoubtable species never attacks any warm-blooded animal. The fact is, that none of the numerous species of ordinary Leeches possess a cutting apparatus at all comparable to that bestowed upon the medicinal Leech. It is true that they possess horny teeth similarly disposed, but comparatively very blunt and imperfectly developed. These Leeches indeed live upon fresh-water snails and other minute animals; they are, moreover, specially fond of earth-worms, which they swallow with great avidity, sometimes even leaving the water in search of them. The structure

of their alimentary canal is likewise very different from that of the species used in medicine, and by no means adapted to form a reservoir of sufficient capacity to permit of very inordinate repletion.

The Leech lays a dozen or sixteen eggs, enclosed in a little cocoon, or common envelope. The cocoons of the common Leech of our ponds (*Hirudo vulgaris*) were, until recently, so little known, that they were regarded by Linnæus in his earlier works as peculiar animals, under the name of *Coccus aquaticus*. The process of the developement of the young Leeches has, however, since been carefully examined, and the following curious facts established by the observations of M. Carena:—This gentleman, while watching some of the Leeches in question that he had confined in a large glass jar, saw one of them carefully employed in fastening its cocoon to the sides of the glass, which it accomplished by pressing it carefully by means of its anterior sucker. The cocoon, when thus deposited, was about two lines * and a half long, covered with a thin skin, and of a yellowish-green colour. In its interior, about a dozen little round, isolated bodies were apparent, which were the true eggs of the Leech. On the sixth day, these gave birth to little Leeches, capable of moving about, although their bodies at this time resembled nothing but little oblong masses of a greenish colour. On the tenth day, they seemed surrounded by a soft transparent substance; and on the twelfth the suckers and the eyes were distinctly visible, although of a reddish

* A *line* is the twelfth part of an inch.

colour. On the seventeenth day, the blood-vessels and internal organs became apparent, and the formation of the body was thus gradually completed. In the mean time, the cocoon had become more and more distended; and, from the first moment that they were able to move, the enclosed Leeches had never approached either end of their prison without pushing it violently with their heads, until at length they had made a sensible impression upon its walls, and ultimately succeeded in breaking it open at each extremity. They then tried to get free; and on the twenty-first day the first managed to creep out. On the twenty-second day, five more followed, and on the twenty-third, all of them had escaped, and were swimming or creeping about in the neighbourhood; their length at that time being about a quarter of an inch, and their thickness not much greater than that of a sewing thread.

The Earthworms (*Lumbricus terrestris*) form another important race of Annelides that breathe by means of internal sacculi resembling those of the leech, an arrangement which is obviously rendered necessary by the habits of these TERRICOLOUS* ANNELIDANS. No external limbs are as yet developed, and yet, strange to say, we find worms so proverbially helpless performing feats without the assistance of such appendages, which other animals would in vain attempt, making their way beneath the surface of the ground with the utmost facility, and with a quickness, too, that to a reflecting mind must seem perfectly marvellous. But in the Earthworm, al-

* Terricolous, *living in the earth.*

though no legs or other locomotive organs are evident to the common observer, Nature has begun to sketch out, as it were, the first rudiments of those limbs that in higher races of articulated animals become gradually perfected. The body of the Earthworm, as is well known, consists of a succession of strong fleshy rings, by the action of which the animal can contract or lengthen itself at pleasure. These rings are generally looked upon as being quite smooth and devoid of outward appendages; a little examination will, however, show that each segment of the worm is furnished with a set of short, horny, recurved hooks, which can be retracted or protruded at pleasure. The points of these hooks are all turned towards the tail, and the effect which such an arrangement will have upon the progression of the animal, will be at once appreciated by the reader. When the worm wishes to burrow through the soil, it forcibly elongates itself, pushing its wedge-like head into the yielding earth. Had it no auxiliary apparatus, the subsequent contraction of the animal's body would only draw the head back again, and nothing would thus be gained by the effort. In this dilemma, however, the hooklets are brought into operation, which being protruded from the creature's sides, take such a firm hold of the surrounding earth as to prevent retrogression, and thus the Earthworm labours on with most effective exertions.

The food of the Earthworm is not a little remarkable, affording another instance of the careful economy every where apparent in the Animal creation, whereby nothing is permitted to be lost

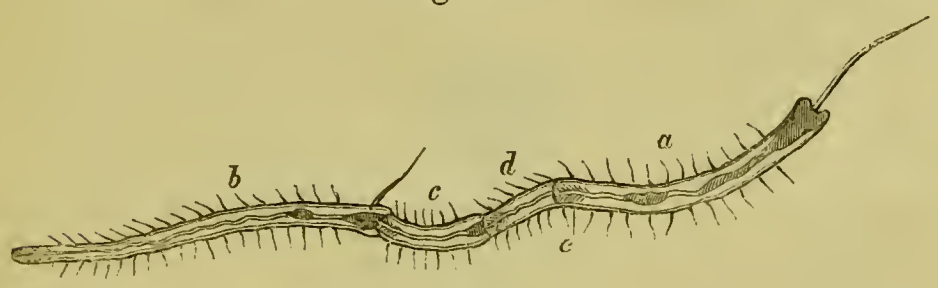
that may be made available as food. The Earthworm as it burrows, swallows copiously the soil through which it makes its way, and its stomach and alimentary canal are generally filled with earth, exactly as the digestive organs of the worm-like Echinoderms were found to be replete with sand. In fact, the same great object is attained in both cases, namely, the reconversion of the crumbs that fall from Nature's bounteous table into a form in which they may be made available as nourishment. Mixed up with the rich soil wherein the Earthworms live, are quantities of vegetable debris in progress of decomposition, which, being swallowed with the earth, are thus converted into sustenance; and when we come to think how many hungry mouths are to be fed with these despised worms, how many birds and fish derive, from such a source, their chief support, we cannot but be struck with the importance of the part performed on the great theatre of animal existence, even by the humblest and most helpless creatures.

Other tribes of the Abranchiate Annelidans, closely allied to the Earthworms in structure, inhabit the mud at the bottom of fresh-water brooks and pools, excavating for themselves holes wherein to live, or sometimes manufacturing factitious tubes by agglutinating foreign particles together. To these worms the general name of *Nais* has been given, in memory of the visionary Naiads that presided over streams and fountains.

The *Nais* (fig. 100) is a simple worm, constructed very much after the same manner as the Earthworm,

to which it is nearly related in many respects. Its mouth is furnished with a long proboscis, wherewith it feeds itself, partially protruding its body from the

Fig. 100.



orifice of the habitation in which it dwells, so as to be able to catch such minute aquatic creatures as are fitted for its sustenance. The most remarkable circumstance connected with the history of these little worms, is their astonishing power of reproducing portions of their body when mutilated by accident or design, or even of dividing spontaneously into two or more individuals. The *Nais proboscidea*, (fig. 100,) for example, after it has arrived at maturity, at which time it consists of only fourteen segments, is further lengthened by the developement of other segments, which are produced in the vicinity of the tail, at a point indicated in the drawing by the letter *e*. These new segments, in time, become separated by a constriction from the original *Nais*, and by the developement of ocular specks and of a protrusible proboscis, speedily declare themselves to be growing into a worm precisely similar to the original; but before the separation between them is accomplished the formation of a third, and even of a fourth *Nais* has been observed, so that four animals, in different

stages of advancement towards perfection, may be found still joined together as represented in the figure distinguished by the letters *a, b, c, d.*

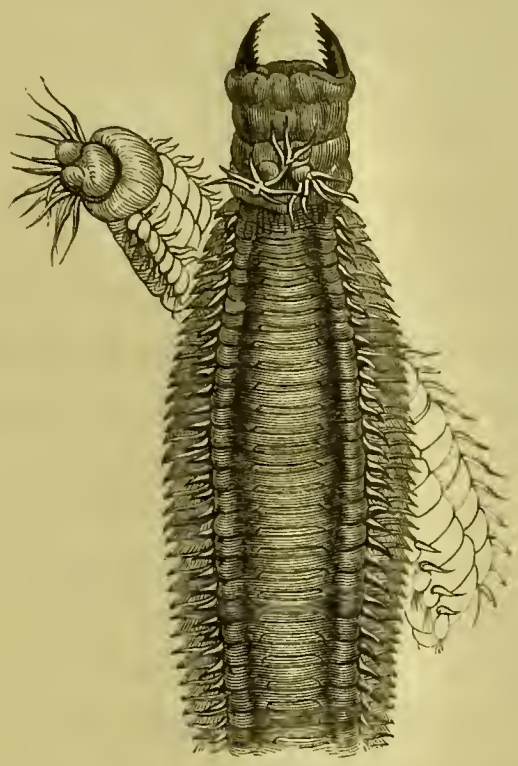
To those who are fond of indulging in curious speculations, this division of the old *Nais* into young ones, presents a very singular phenomenon. As the segments that will form the new *Nais* are produced, not from the tail of the original one, but only in the neighbourhood of the tail, it will be seen that after separation the tail of the old animal belongs to the young one; and when a similar process is repeated to give origin to a third offspring, the same tail is bequeathed as a sort of heir-loom, and so on from generation to generation this immortal tail is transferred from parent to progeny, forming as strictly an *entailed* estate as any eldest son could wish for.

The last and highest division of the Annelidans comprises a series of animals, for the most part destined to lead a more active life than any of the preceding, and consequently Nature has liberally furnished them with instruments of locomotion that were denied to the humbler races, not that their limbs can as yet, in strictness, be called legs; they are rather oars, or paddles, wherewith the worms we are about to consider are enabled to row themselves about in the water, which is their native element; nevertheless, they are such near approximations to legs, that we shall not be surprised, in the next chapter, to find ourselves compelled to bestow that title on organs of a very similar description.

The *Nereis*, (fig. 101,) many species of which are frequently met with upon our coast, will serve as

an example well calculated to illustrate their general history. The body of these worms consists of a consecutive series of rings, all of which, with the

Fig. 101.



exception of the anterior segments that constitute the head, seem to be repetitions of each other, only differing in size, as they taper gradually towards the tail. Upon every one of these rings several external appendages are observable situated on each side of the body. The uppermost of these appendages is frequently a tuft of branching filaments of a bright red or crimson colour, in the living animal; in other cases it is a single stem, to which lateral filaments are attached, giving it a pectinated appearance, as in the specimen represented in the annexed figure; or else in some species the organs in question

are mere vascular prominences or lamellæ, formed by processes of the skin. But whatever may be the shape of these organs, their nature and office is the same; they are almost entirely made up of the ramifications of blood-vessels, and being constantly immersed in the surrounding water, the blood contained in them is thus effectually exposed to the influence of the air contained therein, and respiration adequately provided for. These tufts constitute, therefore, so many pairs of gills, or branchiæ, and, from the circumstance of their being situated upon or near the back of the animal, this group of Annelidans is distinguished by the name of *Dorsibranchiate.**

The other appendages to each segment are subservient to locomotion, and are called the oars; these are generally two in number on each side, one being situated near the back, the other near the ventral aspect of the body. These two pairs of oars are generally separated from each other by a wide interval, but occasionally they are so nearly approximated as not to be readily distinguishable; or there are cases in which only one pair of oars is developed. When perfectly formed, each oar is found to consist of a strong fleshy pedicle, from which there projects an appendage called the *cirrus*, which is of very different shapes in different genera, sometimes being long and filiform; at others expanded into a broad paddle like that of a Sandwich Islander's canoe, or occasionally it may be very small and scarcely perceptible.

* *Dorsum* the back, and *branchia* a gill.

In addition to the cirrus, each fleshy pedicle is furnished with a packet of stiff hairs, or *setæ*, which can be protruded or retracted into the body at the will of the animal: these from their expansion furnish a very important additional surface, and thereby add greatly to the propelling power of the oar, and moreover sometimes constitute a most formidable apparatus of defensive weapons; as, for instance, in the *Aphrodite aculeata*, or *Prickly Sea-mouse*, where the setæ are of great strength and sharpness, each being furnished with numerous barbs exactly like the spears of the Australian savages, so that an assailant must needs be hungry indeed to venture on swallowing such a dangerous morsel.

The muscular covering of the body of these worms is very strong, and being made up of longitudinal, circular, and oblique fibres, very great freedom of motion is allowed in every possible direction; but in addition to the usual muscles which exist in the Leech, and in the Earthworm, there is now a special set of muscles appropriated to the movement of every oar, so that all the lateral instruments of propulsion are worked with a precision and dexterity truly admirable.

It is a beautiful sight to see a man-of-war's barge full-manned with sturdy rowers, gliding along over the level surface of the sea, the oars all keeping time with such precision, that they seem to move as by one impulse. It is a grand spectacle to behold the meteor-like progress of a steam-ship, as it cleaves its onward path, but far more beautiful, far more magnificent to the admirer of the works of Nature,

is it to observe the movements of these splendid worms.

We have before us now a specimen of one of the largest and most elaborately constructed species, the *Eunice gigantea*, measuring upwards of four feet in length, and consisting of four hundred and forty-eight segments, all provided with their complement of oars. Let any one of my readers imagine this gorgeous animal, free in its native seas, blazing as it does with iridescent tints that answer back again the glowing brilliancy of a tropical sun, while it rows along its "oary state" by means of upwards of seventeen hundred distinct propelling laminæ, all wielded with such energy that the eye can scarcely follow the rapidity of their movements, and he will perhaps form some faint idea of the efficiency of a locomotive apparatus such as is provided for the Dorsibranchiate Annelidans. Upon our own sea-coasts, indeed, he may indulge himself by witnessing a similar spectacle upon a smaller scale, and succeed in forming some estimate of the perfection of this complicated machinery.

The Nereids, as might be expected from their activity and erratic habits, are carnivorous animals; and, innocent and beautiful as they look, they are furnished with weapons of destruction of a unique and most curious description. The mouth of the dead Nereis appears to be a simple opening, quite destitute of teeth, which leads into a capacious bag, the walls of which are provided with sharp horny plates, such as we shall afterwards find in the gizzards of some of the higher animals, in which they

are useful in crushing the food before it is admitted into the real stomach. It is not surprising, therefore, that by many anatomists the structure in question was described as a real gizzard, or by some as the stomach itself. A little attention to the habits of the living Annelide will, however, soon reveal the true character of the organ. No sooner does the creature wish to seize its food, than this so-called gizzard is instantly turned inside out, in which condition it protrudes from the mouth like a great proboscis, the teeth, which were before concealed in the interior of the cavity, now become external, and display as pretty an assortment of rasps, files, knives, saws, hooks or crooked fangs, wherewith to tear, cut, bruise, or hold their prey, as any one could wish to see. We give in the annexed figure (fig. 102) a specimen of this apparatus as it exists in *Phyllodoce maxillosa*, from which the reader may easily judge of the formidable character of this strange mouth; it is represented as it appears when fully everted, and the teeth or fangs all ready for action. Let us suppose them when in this condition plunged into the body of some poor heedless victim, while at the same moment the proboscis is rapidly inverted and withdrawn, the prey is seized and swallowed at the same instant, — plunged into a gulph where all

Fig. 102.

struggles are unavailing, and kept there to be passed on into the stomach at leisure.

It is moreover more than probable that the Dorsibranchiate Annelidans that are furnished with such jaws as are depicted in the figure, are not formidable to small animals only—but that, like the Lamprey, they can fasten themselves on living or dead fishes, and bore or tear their way through the skin and flesh, even of large animals, and thus procure a meal at the expense of the lives of their victims.

CHAPTER XVI.

MYRIAPODA.*

Tracing upwards the gradually ascending series of Articulated Animals, we must now prepare ourselves to encounter beings of very different habits from any that have as yet fallen under our notice,—creatures no longer restricted to be inhabitants of the waters, as almost all those have been that we have hitherto had an opportunity of describing, but promoted to another element, where their sphere of exertion is much extended, and their powers and capabilities necessarily increased, in accordance with the wider range afforded for the exercise of activity and cunning.

The lowest races of animals, with the exception of the parasitic Worms, are necessarily restricted to a watery medium. To walk upon the earth, or to fly in the thinner element, the atmosphere, presupposes the possession of strong and accurately jointed limbs, capable of sustaining the weight of the body; of muscles precisely arranged, and endowed with energy and power sufficient to wield the newly given locomotive organs, whether they

Myriapod, μυριὰς, 10,000, or many-legs.

be legs with which to walk, or wings adapted to the purposes of flight. Senses, moreover, of a superior character must now be superadded, corresponding with that vigilance and sagacity absolutely essential to the well-being of the occupants of dry land.

A very little reflection will at once teach us how widely different are the circumstances under which the terrestrial and the aquatic races of animals are destined to exist. The inhabitant of the sea or of the pond is buoyed up on all sides by a fluid, the density of which is almost equal to the specific gravity of its own body, and, consequently, the slightest exercise of muscular power is sufficient to accomplish its movements of progression. Plunged in a medium, the very nature of which precludes the possibility of a very extensive range of observation, instruments of refined sense would have been useless, and intelligence or activity far less adapted to the exigencies of its nature than the apathy and feebleness which so generally characterize the various forms of living beings described in the preceding pages.

But, let us regard the transition from the one element to the other in a mechanical point of view, and ask ourselves what alterations would be requisite to transform a *Nereis*, such as was delineated in the last chapter, into a being capable of *walking* upon dry land. The first thing to be done would evidently be, materially to diminish the length and flexibility of its body by decreasing the number of its segments, and bestowing on them additional

firmness and strength. The *Eunice gigantea*, with the four hundred and forty-eight rings into which it was divided, was admirably adapted to the performance of those graceful undulatory movements, exhibited by that magnificent Worm while swimming in its own element, and its seventeen hundred admirable though feeble paddles were abundantly sufficient for its propulsion through water with the utmost ease and elegance; nevertheless, if we were to take this beautiful Worm out of the sea, and put it upon dry ground, an animal so organized could scarcely be expected to walk.

A very trifling modification of the external structure of the *Nereis* is, however, sufficient to convert the aquatic *Annelidan* into a MYRIAPOD, such as we are now about to introduce to the reader's notice. Let the number of rings be diminished to forty or fifty,—let them, moreover, be strengthened by hardening the integument covering each segment until it is sufficiently firm for the intended purpose; and, while the worm-like shape is still preserved, a framework is provided of sufficient strength to admit of the employment of limbs of a higher character than could have been granted before.

The *oars* of the *Nereis* have next to be replaced by jointed legs, of sufficient strength to support and carry the weight of the body, and moved by muscles of adequate energy, and we have an animal well able to creep about on the surface of the earth, and to perform duties adapted to its, as yet, still feeble energies.

Having thus, as far as external structure is con-

cerned, promoted the *Annelide* to a residence on dry land, it must be evident that further important changes must accompany the transformation. In the *Nereis*, respiration was accomplished through the medium of the water by means of the vascular *branchiæ*, or bunches of ramified blood-vessels that

Fig. 103.

were carried upon the back of the animal; but now, the mode of respiration must be totally altered, and *air*, as such, be breathed instead of water. The breathing apparatus given to the *Annelide* would never do for the Centipede; consequently, the whole mechanism must be changed, and a very different set of breathing organs given, adapted to the new conditions under which the Centipede is destined to live, nor can we too much admire the wonderful and elaborate contrivance adopted for the purpose.

Situated on the lower aspect of each segment

of the body are situate two little orifices, called "spiracles," or breathing-holes, into which the air is freely admitted. Every spiracle leads into a small membranous bag, that at once reminds us of the respiratory sacculi of the Leech and Earthworm: but here the resemblance ceases; for, instead of bringing the circulating blood to these sacculi to be renovated by the influence of the atmosphere, in the *Myriapod* nature commences a new plan of proceeding, and here conveys the air through innumerable pipes into every part of the creature's body, supplying every portion of the system with the vital fluid, and thus sketching out a novel kind of breathing apparatus, which, in Insects, is carried to the highest state of perfection.

The air-tubes, or *tracheæ*, as they are called, appointed for the distribution of the air, ramify and subdivide until they are reduced to microscopic minuteness, penetrating all the viscera of the animal, which thus are furnished with the means of respiration as effectually as the different houses of a large town receive a supply of gas, derived through smaller and still smaller branches from the main pipes.

In effecting this general diffusion of the atmospheric air through the body of the *Myriapod*, there is, however, a difficulty to be encountered which, to any one unacquainted with the means adopted, must appear insurmountable. The iron and leaden pipes, through which the gas is conveyed in the familiar illustration we have just made use of, are unyielding and inflexible, so that the cavities within

them remain permanently open and permeable at all times. But it will be at once perceived that, inflexible and unyielding pipes could never be admitted into the composition of an animal body, where pliability and softness are absolutely indispensable, for reasons that must be obvious to every one. And yet, on the other hand, thin, membranous, or soft canals could not, in a case like this, be made to answer the purpose intended, seeing that they would be liable to continual pressure, which would infallibly obliterate their cavities, and prevent the air from passing through them; thus, of course, causing the suffocation of the animal. The problem therefore is, how to combine flexibility and rigidity with each other,—to provide tubes so pliable, that they may enter into the composition of the most delicate viscera of the body, and at the same time so unyielding, that they shall not be compressed by the distention of neighbouring parts or the action of the muscles.

The ingenuity of Man has enabled him to discover one means of combining these two apparently incompatible qualities, in the construction of pipes which he employs for certain mechanical purposes. Into a leathern, or other flexible tube, he introduces a spiral coil of wire, the stiffness of which is sufficient to prevent the walls of the tube from collapsing, without interfering much with the flexibility of the pipe. Little, perhaps, did the inventor of this ingenious scheme imagine how long the contrivance had been anticipated, and how infinitely the execution of it was surpassed by the Designer of

an Insect's *tracheæ*. Take any fragment of one of these air-carrying canals from trunk or branch — from the main stem to the most microscopic ramification—and you will soon perceive, by the aid of a microscope, that a most delicate elastic filament, a wire of almost invisible dimensions, coiled in close spiral turns extends from end to end of its whole length, giving sufficient firmness to keep the bore permanently patulous, and at the same time allowing all freedom of motion in every possible direction.

The *Julus terrestris* above represented (fig. 103) and other *Myriapods* of kindred form are by no means uncommon in the sandy districts of our own country. The body of the species figured in the wood-cut consists, at maturity, of from forty-two to forty-seven annular segments, of a hard crustaceous texture, to most of which two pairs of thin and thread-like legs are appended, so that the creature walks, or rather seems to glide, along the ground, supported on no fewer than from eighty to a hundred pairs of feet; from which circumstance is derived the name by which they were distinguished by the physicians of former times, with whom a tea-spoonful of their bodies dried and reduced to a fine powder, was, if not a very efficacious, at least a favourite prescription.

The legs of the *Julus*, although still very feeble and rudimentary, are a great improvement upon the locomotive appendages of an *Annelide*. They are, it will be seen, composed of numerous small pieces, united to each other by movable joints, and, in short, are evidently constructed after the

same model as those of Insects, and other more elevated Articulata.

Too weak as yet to be endowed with carnivorous propensities, the Julus contents itself with diet more adapted to its feebleness. It hides itself beneath the ground in sandy places, or in woods under the roots of plants, or else it lurks beneath the bark of trees that are in progress of decay. Its food consists of fruits, or it devours the roots and leaves of succulent vegetables, or such decaying substances as fall in its way. To enable it to feed upon such hard materials, it must be quite evident that its mouth must be constructed upon very different principles from that of any Annelidan described in the last chapter, and accordingly a new kind of mouth is now adopted, differing very widely from anything of the kind that we have as yet seen, but forming the commencement of a long series of mouths given to the insect races, which, although converted to infinitely various uses, are all constructed in accordance with the same plan. The mouth of a *Julus* consists of a pair of strong horny plates, resembling the blades of a pair of shears, the edges of which are furnished with sharp tooth-like appendages. These jaws do not move like our own, up and down, but from left to right, and from right to left, their cutting edges meeting in the middle, so that by their action they can easily slice off portions of whatever the animal chooses to feed upon.

But besides this new kind of mouth, other new organs make their appearance for the first time in these Myriapoda, with the nature of which we shall

be familiarized as we advance. These are connected with additional senses, that Nature begins to bestow upon beings now become sufficiently active and sagacious to make use of them.

The first of these that will require our notice are the instruments of vision. We have again and again had occasion to mention certain red specks seen upon some of the lower animals, upon which the name of *eyes* has been most gratuitously bestowed, and to express our doubts as to the applicability of the term. In the articulated division of the Animal World, there is no longer any room for hesitation upon the subject,—real eyes are for the first time provided, and by degrees become perfected to such an extent, as will hereafter excite our utmost admiration. Nevertheless, when first bestowed, these eyes are of a very simple character. We encounter visual organs indubitably entitled to the name for the first time in the Leech. In that worm they consist of eight or ten little black specks, scarcely visible without the assistance of a magnifying glass, which are situated on the sucking surface of the disc which is appended to the anterior extremity of the creature's body, at a little distance above the mouth. That these specks are true eyes there is no doubt, seeing that every one of them receives a special nerve derived from the brain; neither will the oddity of their position surprise us when we consider the habits of the animal, as they are evidently placed in the best possible situation for perceiving food, or examining the surface upon which the Leech is about to attach itself.

In the *Nais* and in the *Nereidæ* likewise, similar black spots are seen occupying the usual situation of the eyes on each side of the head, and doubtless serving, however imperfectly, as organs of vision.

In the *Julidæ,* whose history we are now discussing, the ocular apparatus assumes a more imposing form, sketching out, as it were, future improvements to be effected in more highly gifted races. It consists of a group of eyes clustered together on either side of the head, evidently analogous in structure to the simple eyes of insects, the structure of which will be described at a future opportunity.

The other instruments of sense, that now make their appearance for the first time, are of a much more mysterious character. These are the *antennæ,* or feelers as they are vulgarly called, which are appended to the fore part of the head, and seem to be specially appropriated to the exercise of the sense of touch. In the Julus these organs are slender threads, slightly thickened towards their extremities, each consisting of seven little cylindrical joints, but in other genera of Myriapods, and more especially in insects, they assume a vast variety of forms, insomuch that they afford the entomologist very important characters to guide him in his difficult task of discriminating species. What may be the real nature of these appendages, or the precise uses to which they are subservient, will perhaps for ever remain a mystery. That they are organs of touch there can be no doubt, seeing that they are constantly employed to palp and feel any obstacle that the animals possessing them may encounter in their

progress, or to explore the way before them as they creep along. The antennæ, however, are something else besides mere tactile instruments; they seem, for instance, to be intimately connected with the sense of hearing, perhaps because their sensibility is so exquisite that they can appreciate the sonorous impulses conveyed through the medium of the atmosphere. They constitute likewise a means of conversation, whereby insects can communicate with each other, as it were, by some strange language of their own, not expressed by words, but rendered intelligible by contact. The uses of these antennæ we shall have abundant opportunity of discussing hereafter; let it suffice at present to indicate the first appearance of these wonderful organs as we approach the confines of the Insect-world.

The MYRIAPODA differ from real Insects in several important particulars, although they are generally looked upon by entomologists as forming a part of that great group of the Animal Creation. The real INSECT in its perfect state has never more than six legs; the Myriapod may possess a hundred and fifty or more. The Insect never grows, or changes the form or number of its limbs after it has once assumed its real, or imago state. The Myriapod, on the contrary, goes on continually growing and increasing the number of its segments and legs during almost its whole lifetime, or at least till it has attained the maximum number allotted to its species. The manner in which these legs grow, and the rings of the body become multiplied, forms, therefore, a very curious and interesting portion of the history

of the creatures at present under consideration, and to this subject we now proceed to invite the attention of the reader.

We have, in a preceding chapter, stated the somewhat astonishing fact, that all the higher animals as they advance to maturity, have to go through the different stages of development in which animals beneath them in the scale of nature permanently exist. In the Myriapoda we have a further illustration of this grand law, and moreover have displayed before our eyes the means whereby such wonderful changes are accomplished. It is to the patient researches of Mr. George Newport, that science is most deeply indebted for the elucidation of the wonderful phenomena, upon the examination of which we are now entering; and seeing that the facts brought to light by our distinguished Entomologist will be found hereafter of the utmost importance in explaining the metamorphoses of Insects, we proceed to lay before the reader Mr. Newport's discoveries, and trace the Myriapod from the egg to its perfect condition.

When about to deposit her eggs, the parent Julus is exceedingly diligent in preparing a safe and appropriate place of concealment, burying them in a kind of burrow, which she constructs with no little toil and perseverance, as will be seen from the following account of her proceedings given by Mr. Newport.* She first digs a cylindrical hole to the depth of about an inch, and only just large enough to admit her body, and excavates at the bottom a

* Phil. Trans. for 1841.

little circular cell, or chamber, by digging out the soil, grain by grain, with her mandibles and anterior pair of feet; when she has excavated the burrow to its proper depth, she remains for a few minutes with her head and the anterior half, or two-thirds of her body, in the hole, as if resting from her toils, with the posterior part exposed at the surface, to enable her to cling by her feet to its margin, and thus afford her support in bringing up the soil she is removing from the bottom. Having continued in this situation for a few minutes, she again resumes her labours. In about a minute she gradually withdraws herself backwards from the hole, bringing up with her a little pellet of moistened clay, which she holds between her first pair of legs and the under surface of her head. As soon as it is brought to the margin of the hole, it is passed backwards to the second pair, and so onwards to the next in succession as it reaches them, until it is removed entirely out of the way. She then immediately reenters the hole, and this operation is repeated many times until she has excavated a chamber at the bottom sufficiently large for her purpose.

No sooner are the eggs thus laboriously buried hatched, than a series of phenomena of the most interesting kind may be witnessed. The young when first born, (fig. 104,) so far from being at all like their many-legged parent, have no legs whatever, or at least such rudiments of them as are quite unfit for locomotion. When still further advanced it has but three pairs, subsequently seven pairs; at a later period the number of legs progressively increases by

repeated additions of two or three pairs at a time, until the full complement is granted.

This continual addition of new legs would in itself be a fact sufficiently wonderful to attract the attention of the most superficial observer; but when we are informed by the researches of Mr. Newport how Nature accomplishes not only the development of successively bestowed limbs, but even the gradual building up of the various portions of the body, no apology is requisite for laying before the reader the following abstract of that gentleman's observations.

The eggs of the Julus when first laid, present, when examined under the microscope, the essential structure alluded to in a preceding chapter, the shell, the granular yolk, with its delicate envelope, (104. 1. *a*,) and the germinating vesicle, (104. 1. *b*,) all being easily recognisable. If examined on about the twenth-fifth day after it has been laid, the young Julus is distinctly visible in its interior; not as yet, indeed, exhibiting anything like the shape of the parent Myriapod, but rather resembling a worm of the simplest possible structure, without any appearance either of limbs, or rings, or antennæ, or eyes, but precisely exhibiting the condition of one of the humblest forms of the *Sterelminthoid Entozoa* described in a preceding chapter. In this condition the egg-shell bursts, and the little creature enters upon a new state of existence.

Still, however, it is by no means sufficiently perfect to be set entirely free, but remains for a number of days enclosed in a most delicate, transparent, membranous covering, within which the next part of

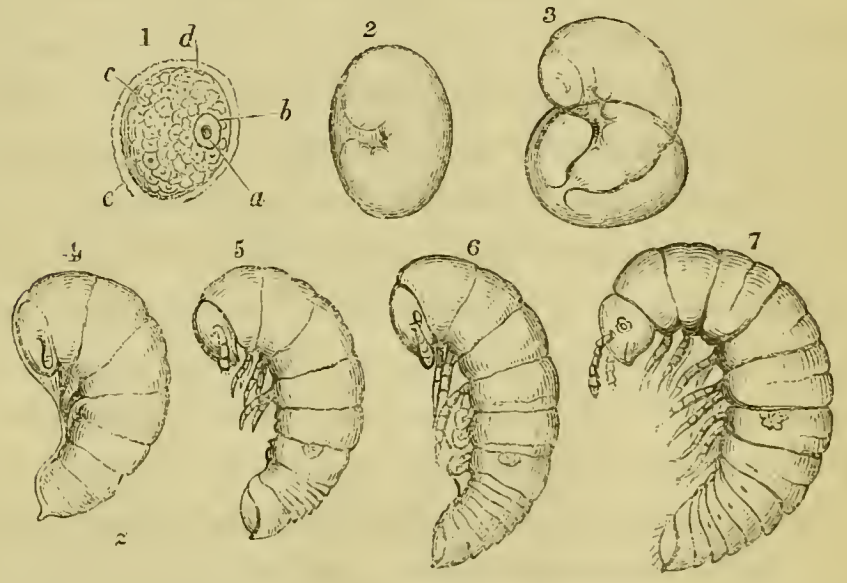
its growth is accomplished, although from the circumstances it is placed in, there is no possibility of its being supplied with other nutriment than the moisture imbibed through its investment.

In this situation, nevertheless, great and astonishing changes are observable in the condition of the worm, as the observer watches it from day to day; almost every hour manifesting some additional advancement in its growth. Its body, even on the third day after the bursting of the egg-shell, is seen by the microscope to be entirely made up of germinating cells, the materials out of which all the structures subsequently developed have to be formed. These cells are of three different sizes, some being comparatively very large, others of smaller size, as though produced by the breaking up of the former; and others again extremely small, as if produced by the further subdivision of the second into cells sufficiently small to become the materials whereof all the future organs of the body have to be constructed. Miraculously to behold, these microscopic cells assume a more and more definite arrangement, every hour revealing the first traces of some nascent structure; the cavity of the future stomach may soon be recognised, muscular fibres gradually become apparent, a single little speck is formed upon the side of the head, which speedily reveals itself to be a solitary eye; *antennæ* begin to bud from the forehead of the little embryo, the surface of the body becomes marked with indentations, the first indications of the rings or segments of which the body is to be formed, and from the first rings thus made apparent,

three pairs of little legs begin to sprout, which becoming every day more and more perfect, they assume their full proportions, although still bound close to the body, like the limbs of an Egyptian mummy, by the membranes in which the little Myriapod is swathed; nor until the seventeenth day is the creature ready to escape from its imprisonment, and enter upon its third state of existence.

On escaping from the investments in which it has been so long confined, the young Julus presents itself in the condition delineated in the fifth figure of the subjoining woodcut (fig. 104). The segments

Fig. 104.



of its body are more decidedly marked, and the most anterior even present indications of that subdivision into two half segments, which are so characteristic of the adult animal. The little Julus at this time consists of eight segments, exclusive of the head; of these the first three are provided with feet, whilst all behind are entirely destitute of such appendages.

We must now, however, call the reader's special attention to the seventh segment, the last but one, which in the figure is indicated by the letter *z*. This segment is in fact the part by which the future growth of the animal is entirely effected, and the number of its rings increased until they attain the maximum number appointed by Nature. This part of the body, which is always situated immediately in front of the last segment, or tail as we might call it, is continually growing and forming new rings, six at a time, in the manner we will now endeavour to explain. The little *Julus*, which on the seventeenth day presented the appearance delineated in the figure at 5, by the twenty-first day has attained the condition exhibited at 6, where we may remark the following circumstances: First, that three new legs have grown from the fourth, fifth, and sixth segments, which, however, remain as yet closely packed up beneath the skin. Secondly, that the germinating segment has grown into six new segments likewise, at present concealed beneath the integument. In this state the young Myriapod prepares to cast its skin, which it effects much in the same manner as caterpillars and other larvæ of insects; and no sooner is the old skin thrown off than the creature appears as shewn in the figure at 7, with six pairs of legs instead of three; and, moreover, seven new segments without legs behind them. In this state it remains for some days longer, moving about with progressively increasing facility. Meanwhile the same process is silently going on, six new legs sprout from the segments last formed, and six new

segments are in progress of formation by the germinal segment, so that at the next change of skin the animal makes its appearance with eighteen legs, and six additional segments, and so on, the same number of legs and segments being added at every change of the skin, until the number proper to the adult animal be complete. Thus, therefore, we have in the Julus an opportunity of witnessing the limbs and rings developed by regular instalments; and when we come to reflect upon all the circumstances involved in this progressive multiplication of superadded limbs, the formation and disposition of all the new muscles required for the movements of each, the nerves, the vessels, the air-tubes, the joints, well may we be lost in wonder at the contemplation of such mysterious phenomena.

The senses likewise are gradually perfected as the growth of the Julus advances. At first, as has been stated above, a single speck on each side of the head was the representative of the future eyes. As the little animal becomes more complete, the visual organs likewise are slowly perfected. The original eye enlarges in its dimensions, assumes a triangular shape, and ultimately resolves itself into six distinct ocelli, or simple eyes, grouped together in such a way, as already to sketch out the more elaborately constructed eyes bestowed on the true Insects. All the details connected with the developement of the Julus are, in short, of the highest interest to the physiologist, and furnish, as it were, a kind of key wherewith to explain the more intricate phenomena witnessed during the metamorphosis of Insects.

The Julidæ, with their numerous and feeble legs, are unable to do more than creep slowly from place to place; and, being quite powerless in attacking living prey, are obliged to content themselves with feeding on such vegetable substances as they may be able to procure. But having advanced so far in improving the structure of the articulated races of animals, as to confer upon them ambulatory organs and instruments of sense of a refined character, it becomes an easy matter, by following out the same principles a little further, for Nature to confer upon the Myriapoda such strength of limb and activity of body as to make them formidable antagonists to other animals, whether insects or otherwise; and, at the same time to improve their powers of vision and their other senses, until they approximate the Insects themselves in their instincts and habits.

The changes required to convert the slow-moving and vegetable-eating Julus into an animal endowed with sufficient energy to enable it to live a life of warfare and rapine, will, after what has been said in preceding pages, at once suggest themselves to the reader. A further concentration of the different parts of the body must be effected by reducing the number of segments, and increasing their proportionate size, to such an extent as will admit of the employment of stronger and more vigorous muscles wherewith to move the ambulatory limbs. The legs themselves must be made longer, and of greater power; and lastly, the senses must be made more acute, in order to put the destroyer on an equality with the prey it is destined to grapple with.

It is sufficient to point to the accompanying figure (fig. 105) representing the *Scolopendra*, one of the carnivorous Myriapoda, to convince the reader that

Fig. 105.

in its construction, all the above conditions have been scrupulously fulfilled.

The SCOLOPENDRIDÆ, or *Centipedes*, forming the second great group of the Myriapoda, are, in fact, animals which we instinctively acknowledge to be of very formidable construction, and from the size to which they frequently attain, some of them in our cabinets measuring upwards of a foot in length,* it is by no means surprising that man himself does well to be upon his guard in regions where these creatures abound, lest he should come into unpleasant proximity with such redoubtable monsters.

* Dr. Martin mentions having seen a Myriapod related to this genus which measured eighteen inches in length and three quarters of an inch in width, having ninety five legs on each side of its body; and Ulloa states that he had seen a kind of Julus which

In our own country the centipedes are fortunately all of small size; but their habits and instincts are similar to those of their gigantic congeners, brought from warmer climates. They are able to run very quickly, generally shunning the light, and hiding themselves under stones or old beams, beneath the bark of trees, or sometimes burying themselves in the earth, or in heaps of manure. It is, in fact, in such situations that they are, from their general construction, best adapted to reside, their long and flexible bodies being admirably fitted to worm their way through the narrow windings of the labyrinths, where, doubtless, they find abundance of food, such as they are in quest of: what means they possess of attacking and destroying their victims we will now proceed to examine.

In the *Scolopendra morsitans*, of which the preceding figure is a portrait, the body consists of two and twenty segments, including the anterior one, which constitutes the head. To the sides of each segment is appended a single pair of long, robust, and well-jointed legs, so that the creature has one and twenty pairs of these locomotives at its disposal.

The creature's mouth is armed with strong, cutting, horny jaws, resembling those of the Julus, and in themselves very formidable weapons of attack, but

sometimes exceeded a yard in length and five inches in breadth! No collectors, however, that we are aware of, have been lucky enough to get a glimpse of the last-mentioned monstrous species, or doubtless it would cut a figure in our cabinets in spite of the deadly venom with which it is stated to be armed.

to these, a pair of dreadful looking instruments are now superadded, the nature of which cannot for a moment be doubtful. On the sides of the mouth is placed a pair of strong, curved, and sharp-pointed fangs, which move laterally, so that their points meet each other in front of the face. This pair of pincers is moved by muscles of tremendous strength, so that woe betide the poor animal into which the blades are plunged. Each of the fangs is, moreover, perforated near its point by a little orifice, which communicates with a bag of poison concealed within, so that exactly in the same manner as the viper instils its venom at the moment when it inflicts a bite, the Scolopendra ejects into the wound which it inflicts a drop of this deadly secretion, which doubtless proves instantly fatal to the smaller animals, upon which the Myriapod generally feeds, and even renders the consequences of a bite from one of these creatures dangerous to man himself. The breathing organs of the Scolopendra consist of a series of spiracles, or breathing holes, visible in the lateral margins of the different segments of which its body is composed, from which tracheal tubes, exactly resembling those of the Julus, convey the atmospheric fluid to every part of the interior of the body.

In conformity with this mode of respiration, so very different from what exists in any form of Annelidans, it has been found necessary in the Myriapoda entirely to remodel the apparatus provided for the circulation of the blood, which now presents a most novel and curious arrangement. Running

along the whole length of the back of the Centipede, there is a long pulsating vessel, exactly resembling the dorsal vessel seen through the transparent integuments of the silk-worm, or any other thin-skinned caterpillar. The tube in question exhibits continual movements of contraction and dilatation, the contraction beginning at the tail, and advancing forwards towards the head, so as to present a constant undulatory movement, whereby the fluid contained within it is perpetually driven forward from the tail towards the head.

On examining this vessel more closely, it is found to have wide openings in its sides, corresponding in number to the segments of which the body consists. These openings are all furnished with beautiful valves which, while they freely permit fluids to enter the vessel from without, accurately close the orifices so as to prevent it from escaping again. Other valves of similar construction are so disposed in the interior of the dorsal tube, as to allow its contents to flow freely from the tail towards the head, but absolutely to interdict its passing in the opposite direction, so that the undulatory movements of this remarkable heart must always propel its contents forwards towards the anterior part of the body.

In the vicinity of the head the dorsal heart terminates by dividing into several arterial tubes, which wind round the commencement of the alimentary canal, and finally terminate by forming a large arterial trunk, which runs beneath the stomach and digestive tube back towards the tail, giving off in

its course numerous branches to supply the whole body with blood.

After being thus distributed, the blood escapes into large cavities excavated between the muscles and other organs, and at length accumulates in a chamber which surrounds the dorsal heart, in readiness again to enter the valvular openings situated in the sides of that viscus, to be once more impelled through the same course.

Several species of the Myriapoda are remarkable for peculiar secretions, given either for the purposes of defence, or to facilitate the capture of their prey. The common Millepede *Julus terrestris,* for example, secretes from pores situated upon the sides of its body a fetid fluid, which strongly scents the hands of any person who may handle the living animal.

A species of Scolopendra, often found in this country lurking under clods of earth, the *Geophilus electricus,* is in some mysterious manner enabled to give a pretty smart electric discharge, distinctly to be felt, and even sometimes strong enough to make the young naturalist drop a specimen that he may have laid hold of; such being the case, there can be little doubt that a discharge of this living battery may have very great effect in stunning or paralysing the prey upon which these Myriapods live, much in the same manner as the Torpedo and the Gymnotus can employ their galvanic apparatus.

The species above mentioned, *Geophilus electricus* has likewise the power of emitting a strong phosphorescent light, by which it may frequently be discovered during the night time in our gardens.

This phosphorescence is emitted, not from any particular spot, as is the case with shining insects, such as the Glow-worm, Cucujo, &c., but from the whole surface of the body, thus perfectly revealing the shape of the animal. It seems to depend upon some luminous secretion that exudes from the surface of the body; a supposition rendered more probable from the circumstance, that the luminous matter will adhere to the fingers of any person who may seize hold of the Geophilus while it is shining, causing them to shine, as if rubbed with phosphorus, for some seconds afterwards.

Another luminous species is mentioned by Linnæus under the name of *Geophilus phosphoreus*, upon the authority of Captain Ekeberg, a Swedish naval officer, who stated that, when sailing in the Indian Ocean upwards of a hundred miles from the land, a specimen fell upon the deck of his ship, which shone with surprising brilliancy. We have certainly heard of showers of frogs and showers of fishes, which seem to have been snatched up by a water-spout, together with the pools in which they lived; and it seems not absolutely impossible that during an Indian tempest, the storm might blow a poor wingless Centipede all that distance out to sea; nevertheless, it seems more reasonable to suppose that the Captain, misled by the similarity of form, mistook some *Nereis* that the waves had thrown on board his ship for a real Myriapod, more especially as many of those marine Annelidans are eminently phosphorescent light, and shine in the dark with uncommon brilliancy.

From what has been stated relative to the organization of the Myriapoda, the reader will by this time have perceived that, although in their shape and general characters they are very distinct from the Insects properly so-called, a progressive advancement has been made which brings them very near to that great and important class of animals. The Scolopendra, with its long and pliable body, would evidently be as incapable of using wings for the purposes of flight, as the Annelide was found to be of wielding legs wherewith to walk upon the ground; but by carrying the process of concentration a little further, the transition from one class to the other is easily effected. By reducing still more the number of segments of which the body is made up, it becomes now easy to consolidate and strengthen the external framework sufficiently to permit of the superaddition of those organs of flight which form the great distinguishing character of the true Insect races.

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