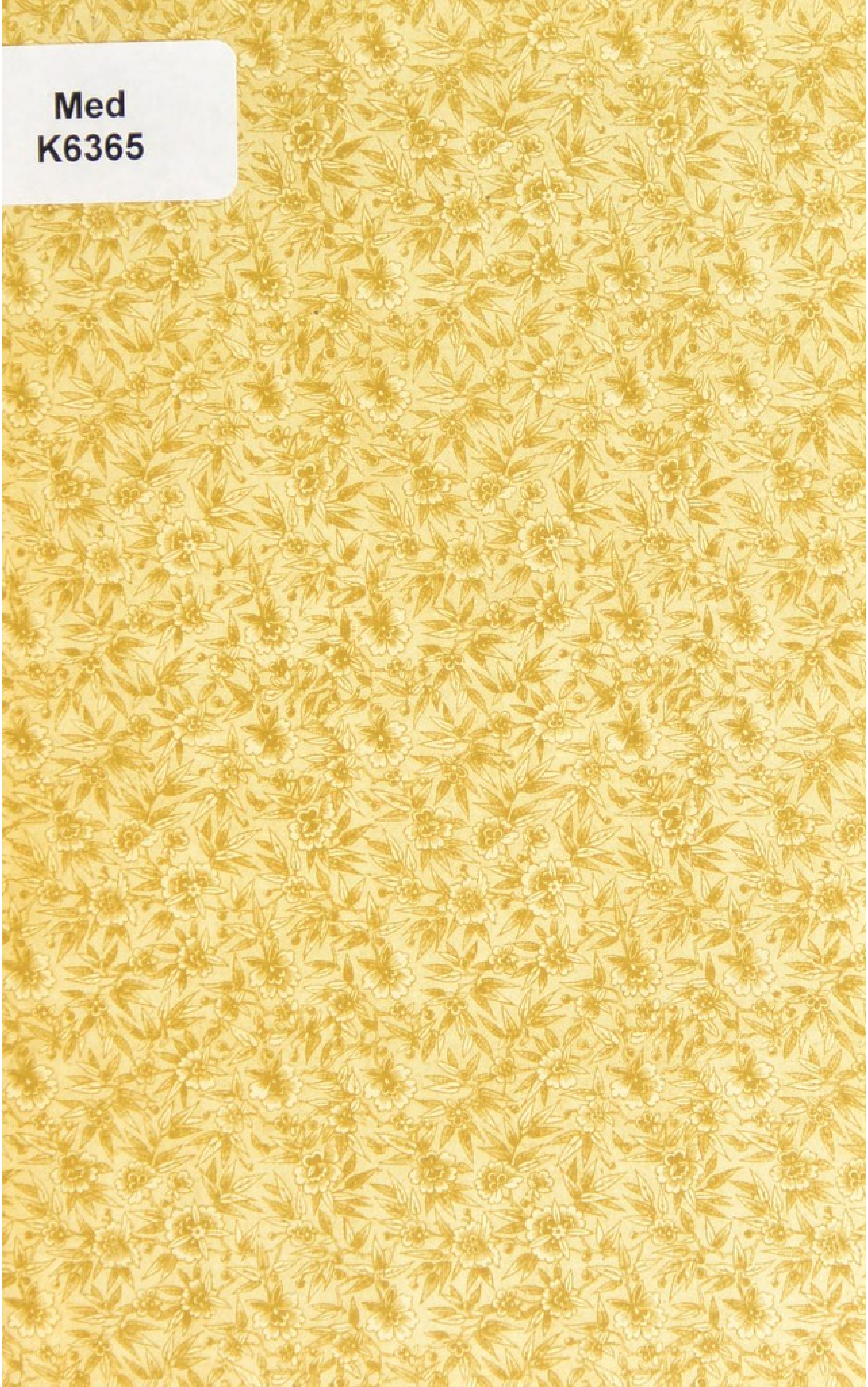
HIDDEN BEAUTIES OF NATURE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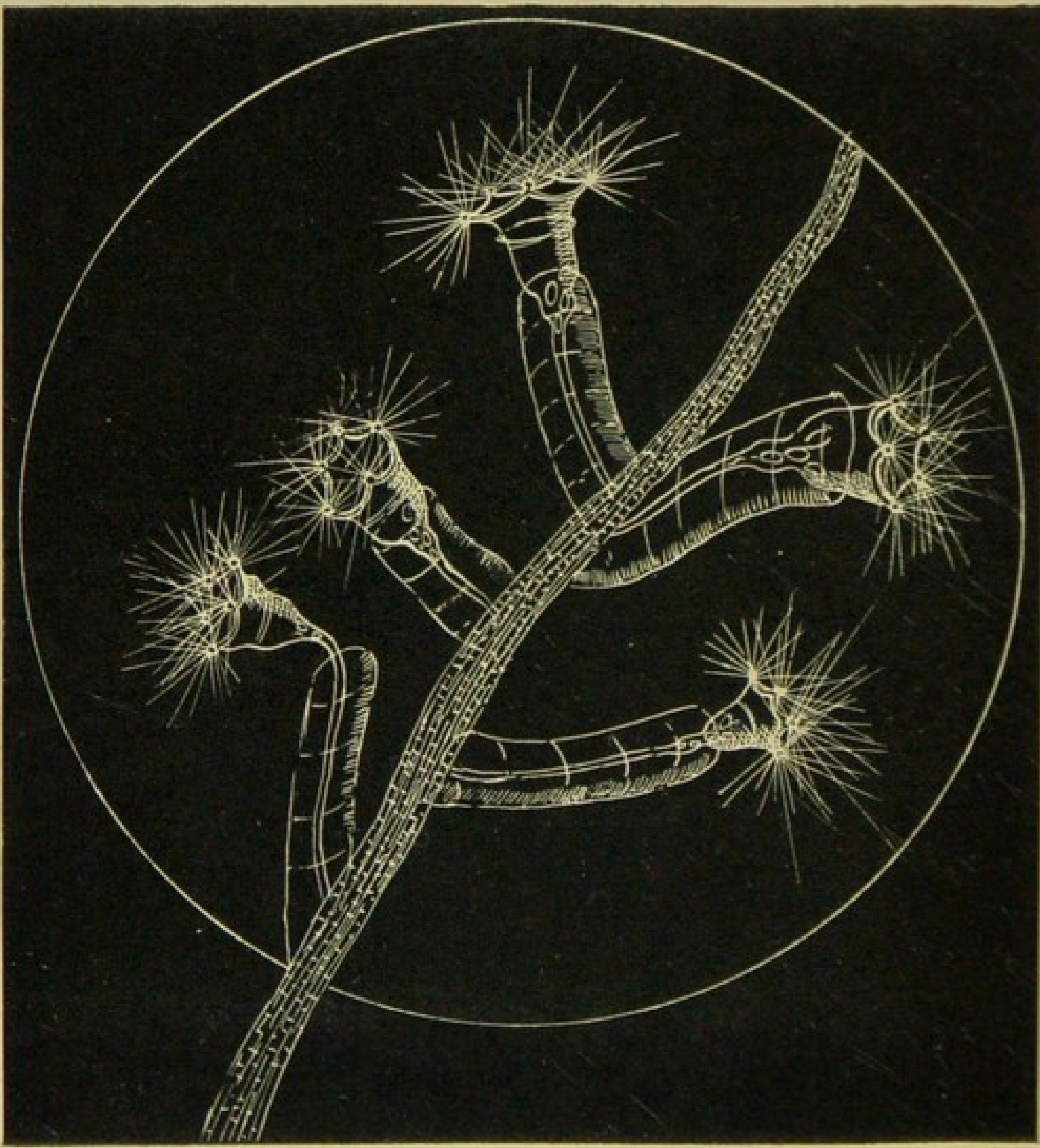

'The Beautiful Floscule' (Floscularia ornata). Below the range of unassisted sight.

HIDDEN BEAUTIES OF NATURE

BY

RICHARD KERR F.G.S

WITH FIFTY-NINE ILLUSTRATIONS
FROM SKETCHES AND PHOTOGRAPHS

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'In the beginning God created the heavens and the earth.'—GEN. i. 1.

'And God saw everything that He had made, and, behold, it was very good.'—GEN. i. 31.

'O Lord, how manifold are Thy works! in wisdom hast Thou made them all.'—Ps. civ. 24.

'He hath made everything beautiful in its season; also He hath put it into their hearts to observe the world, without which no man can find out the work that God maketh from the beginning to the end.'—ECCLESIASTES iii. 11.

'These are Thy glorious works, Parent of good,
Almighty! Thine this universal frame,
Thus wondrous fair; Thyself how wondrous then!
Unspeakable, who sitt'st above these heavens
To us invisible, or dimly seen
In these Thy lowest works; yet these declare
Thy goodness beyond thought, and power divine.'

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

THE following chapters contain, in simple language, the main points of lectures delivered to scientific societies, to colleges, and upper-class schools, and to large audiences in several parts of England. As the lectures have influenced not a few to form collections of suitable objects of natural history, and also to purchase microscopes to enable them to pursue their studies with success, I am hopeful that the following chapters will lead a still greater number to take up some department of Nature as a definite study. This elementary introduction to the microscopical side of creation is an effort to persuade others to adopt a line of useful reading and research, which must give to them much pleasure.

The occupation of spare moments in searching for hidden beauties of Nature is both pleasant and profitable for young people. Unawares, and without irksome toil, they are sure to add to their store of information, to say nothing of the mischief avoided through being intelligently occupied. No study is easier than that of Nature, and it is so varied that all tastes may find congenial employment when engaged in trying to unfold her mysteries. It is attested by those competent to judge, that works of Nature are more beautiful, more accurate, and more astounding than any work that man can produce. It would appear also that the hidden beauties of Nature are intended for our study, edification, and pleasure. To become acquainted with them ought also to become a duty.

The tendency with a great number of people is to disregard Nature's wonders, and to select for their reading the light literature of the day, often very trashy and pernicious novels, instead. The gift of eyesight and the power to use the mind were intended for better studies.

Thousands of people pass through the span of life without ever having had the pleasure of seeing for themselves the surrounding loveliness of created things. How true, even in this respect, is the ancient saying, 'Eyes have they but they see not!' The philosopher's words are as true to-day as when they were first uttered: 'A nation's greatness depends upon the education of its people.' There is a great deal in that word 'education.' And it will be well to bear in mind that all we learn at school does not comprise an education; this is only a fraction of what the word embraces. Whatever else the word may include, the study of Nature ought to be a part of it. We are inseparably connected, inseparably linked with Nature, hence it is impossible that the course of study in any school or college can be complete, or fairly satisfactory, which does not include a general knowledge, at least, of the astounding facts with which we are surrounded, and of which we form a part. The aged statesman's reply to the request that he would become an honorary member of the Guildford Natural History and Microscopical Society is worth repeating in part here :—[1] 'I think that the neglect of Natural History, in all its multitude of branches, was the grossest defect of our old system of training for the young; and further, that little or nothing has been done by way of remedy for that defect in the attempts made to alter or reform that system.'

There can be no difference of opinion as to this great man's profound scholarship, hence his words ought to promote the study of Natural History. Believing that the interpretations of the Creator's plans in Nature are too frequently left to those who disbelieve in the existence of an all-wise God, it behoves those who see God in Nature to make the fact known whether by lectures or in their writings, and to point out to young people that all the great problems in creation are the result of Divine wisdom, and that what we do not now understand, in that our mental powers are finite, will be made clear in the future, for the finite cannot fully comprehend the Infinite.

[1] Mr. Gladstone: *The Standard*, January 11, 1895.

In the following pages I simply state my own impressions of what I see in Nature; with the aid of the microscope, the geologist's hammer, and the eye of an obscure artist, I give expression to the feelings Nature's wonders inspire in me. I have neither the power nor the desire to follow out all the intricacies of the theory of Evolution. The interpreters, so-called, of the acute and well-stored mind of Charles Darwin do not satisfy one so much as Darwin himself. They often overlook Darwin's own words :—'That probably all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was first breathed by the Creator.'

Through the courtesy of Thomas Smith, Esq., proprietor of *Great Thoughts*, I am permitted to use the title, *Hidden Beauties of Nature*, and several articles contributed by me under that title in one of his other magazines—*Mothers and Daughters.* For several facts concerning the North American fresh-water Rhizopods, as described by the late Dr. Leidy, I am indebted to his friend and co-worker, Mrs. Chase, of Philadelphia, a lady known in English and American scientific circles as an authority upon many departments of Natural History. For information respecting ocean surface forms of microscopic life, I am indebted to the works of Professors E. Haeckel and A. Agassiz. The Rev. Thomas Robinson, of Swansea, has kindly placed at my disposal his observations on the Rosy Feather Star, from which I have made extracts. I have received considerable help, as regards the illustrations, from the Sciopticon Company, of Highbury Quadrant; from Mr. C. W. Locke, the well-known optical lantern and slide maker; and from Mr. E. Horsnaill, the marine biologist, of Dover.

In making these acknowledgments, it is my duty to state that I owe a great deal to the kindness of a friend since departed,[1] who, by giving me a splendid microscope and the standard works on microscopy, when I was a beginner, set my thoughts in the direction in which it is hoped the following chapters will set the thoughts of others.

[1] The late William Ferguson, Esq., of Hornsey Lane.

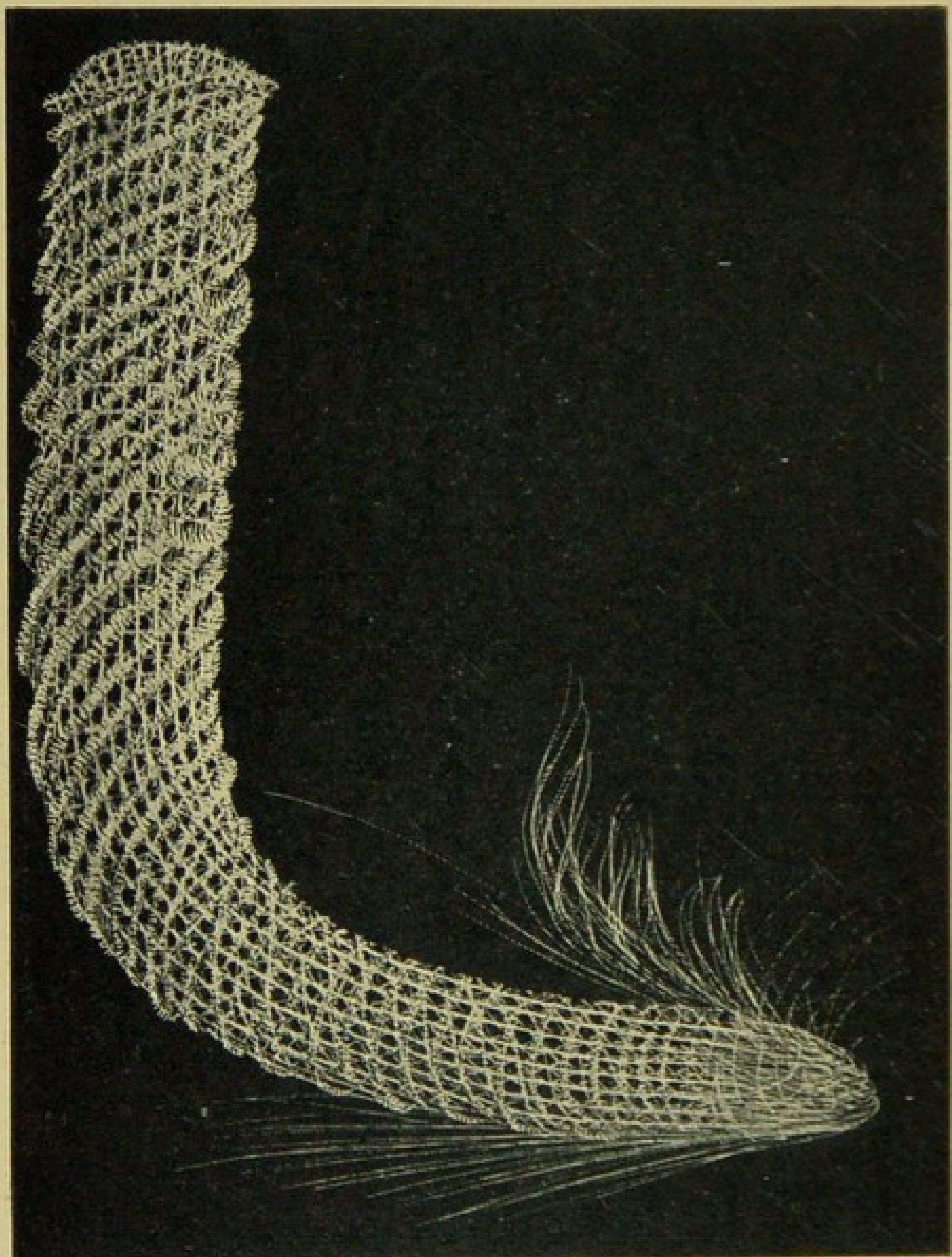

Fig. 2.—Euplectella speciosa.

HIDDEN BEAUTIES OF NATURE

CHAPTER I

ON THE STUDY OF NATURE

THE advanced student, and those who require learned books on animal and plant life, will find nothing in these chapters sufficiently deep for them. But the young beginner who has no particular hobby may be induced to find one among the marvels here noticed. The young people of the present generation have facilities and opportunities of acquiring useful information which never fell to the lot of their grandfathers, yet the temptations to remain ignorant or to go wrong are very great and very numerous. Therefore it behoves us all to so employ our minds that they may be led to think in the right direction; and so train our eyes that they may see what ought to be seen. The following pages have been written with this aim in view, and are especially addressed to young people.

Puzzling definitions, difficult classifications, and many-syllabled names are to many readers, and especially boys and girls, like so many notice-boards, warning them against trespassing in the fields and woods where Nature's hidden beauties abound. Hence the writer has avoided as many as possible of such barriers, and has tried to erect only such notices as may invite and attract young readers to take up some branch of study directly connected with Nature.

In a certain sense all Nature is the common property of all people, whether rich or poor, and there is no royal road to its hidden beauties and wonders. Even the stars in the heavens are one man's possession as much as another's, and may be studied without hindrance. History shows that such studies could not be undertaken with impunity in less enlightened times. We should, therefore, value highly our own great privileges.

The study of the vast and only partially trodden fields of Natural History, whether undertaken in a practical manner or adopted as a pastime, is sure to be productive of much pleasure and utility. Few pastimes are more laudable. We need not hesitate to adopt as our special line of pursuit the study of any particular group of plants or animals, rocks or minerals; for no naturalist, however long he may have lived, or however clever he may have been, has so exhausted any one department of Nature that nothing remains to be explored.

To make the acquaintance of hidden beauties of Nature, we cannot do better than form a collection of suitable objects of Natural History. The work will be pleasant and intelligent. It will give us food for thought. It will assist in drawing our attention away from what is wrong to that which is right. It will arouse our enthusiasm so much, if undertaken in a proper spirit, that there will be no time for idleness. It will form one of the best means of acquiring information, and it ought to ennoble our minds and give us more exalted conceptions of the Creator's power, wisdom, and goodness. For lack of intelligent occupation many young men are drawn into ignoble paths. The lover of Nature, as a rule, is a man of peace, and is often a civilizing factor in a community. His desire is to show and to talk about the wonders with which he is familiar.

The love for Natural History studies led a young nobleman to collect specimens from all known parts of the world. This led to his laying out a large sum of money in the construction of a splendid museum to hold his invaluable collections. The people now enjoy the benefit of his praiseworthy hobby. The process of gathering together the multitudes of objects this museum contains, and the outlay on the erection and fitting up of the building, afforded substantial help to a very large number of people. Visitors to this museum can see many objects of which there are no duplicates in the great national collection at South Kensington.

Its arrangement throughout is entirely educational. That it will prove to be a boon of elevating and lasting character is a foregone conclusion.[1]

Rather than be idle, a workman who gets but intermittent employment at a certain harbour, has made extensive and valuable collections of butterflies, moths, and birds, belonging to his own district, and he lends them for exhibition whenever efforts are made on behalf of any local charity. For a similar purpose a gardener collects sponges, seaweeds, and other seashore treasures, and his cabinets

[1] The Rothschild Museum, at Tring.

and glass cases are filled with lovely things which would have passed away had he not had a desire to search for these attractive objects. He has read about them, and has preserved and classified them.

If a man has no resources beyond the toil of earning his daily bread, no hobby to which he can turn in his spare moments, he is to be pitied, but not envied. The life of Thomas Edward, the Scotch naturalist, ought to be a stimulus to young people, for it shows what can be done by unassisted power.

Judging from the following we can hardly say we have no time for a hobby or pastime. A certain doctor, with a very large practice, which he attends to with the strictest conscientiousness, has, during his short summer holidays, excavated from the chalk cliffs nearly 3,000 fossil specimens. Here again the national collections at South Kensington are eclipsed, for this gentleman has many specimens that are unique. In fact, there is no book printed that contains the names of all of them, so that when he writes his descriptions of them for the learned societies, many of his 'finds' will be new to science. His collection is one long series of hidden beauties, hundreds of the fossils being exquisite beyond description. After such an instance as this who can say he has no time over and above that absorbed in the ordinary duties of life?

Those who do not know how to make a beginning as collectors, may learn from the following incident. Some years ago a gentleman gave me an account of his own experiences. He began life as a poor lad with limited privileges, but with a longing to know something of the objects he saw in a museum. He provided himself with a cardboard box, into which he put specimens of chalk, limestone, iron, coal, slate, a pebble, and a bit of flint. This was the nucleus of his collection. He looked into books for information about each of his specimens, and beginning with the chalk, he became so fascinated that he wrote out a lengthy description of the chalk formation, and proceeded to the study of coal. This too he found intensely interesting, and so on until he became pretty well acquainted with the origin and history of each of the items in his humble collection. At this stage he knew more geology than many people knew who had greater advantages. He added to his collection, and read on as he added. The time came when he read papers before scientific societies, delivered lectures, and helped many beginners to start collecting for themselves. Some years before he died he exhibited valuable objects of interest before the Royal Society. The plan he adopted cannot be beaten even now, with all our advantages, viz. that of having the actual specimens to look at and to examine as he read about them.

Apart from the intrinsic value of the collections referred to, an amount of useful knowledge is gained in an attractive way, and the pleasure afforded to the collectors is real and lasting. All honour to such men. They are useful in their day and generation. They encourage us to put a proper value upon our time, and they teach us the high possibilities that we can attain to if we are not idle.

Those concerned in the education of the young would do well to facilitate any tendency towards Natural History study, and where possible to countenance the making of collections of a suitable character. This gives great interest to school work.

Each locality has its own representative fauna and flora (animals and plants), rocks, and possibly minerals, therefore specimens can be easily obtained. When such objects are classified and exhibited in their own neighbourhood they become quite a revelation to the uninitiated, and in any case are educational. Thus the foundation of small museums might be laid, and collections, if limited to purely local supplies, would be of immense value in scores of different ways. Young people, working men, and others, would learn to notice and collect objects they would have passed by previously.

The Rev. Charles Kingsley was a lover of the beautiful in Nature. He looked upon the flowers, and grasses, and pebbles, and seaweeds as his friends. He wrote about them, and his books will live. The sermons he preached received additional power and illustrative force owing to his knowledge of Nature. A clergyman at the present time, with a practical knowledge of the lapidary's work, has aided very materially in bringing to the notice of the people the marvels of Nature trodden underfoot on the sea beach. The very pebbles, in which ordinary mortals would never expect to find anything deserving of notice, contain hidden beauties, and when polished are worthy of a place in the cabinets of kings.

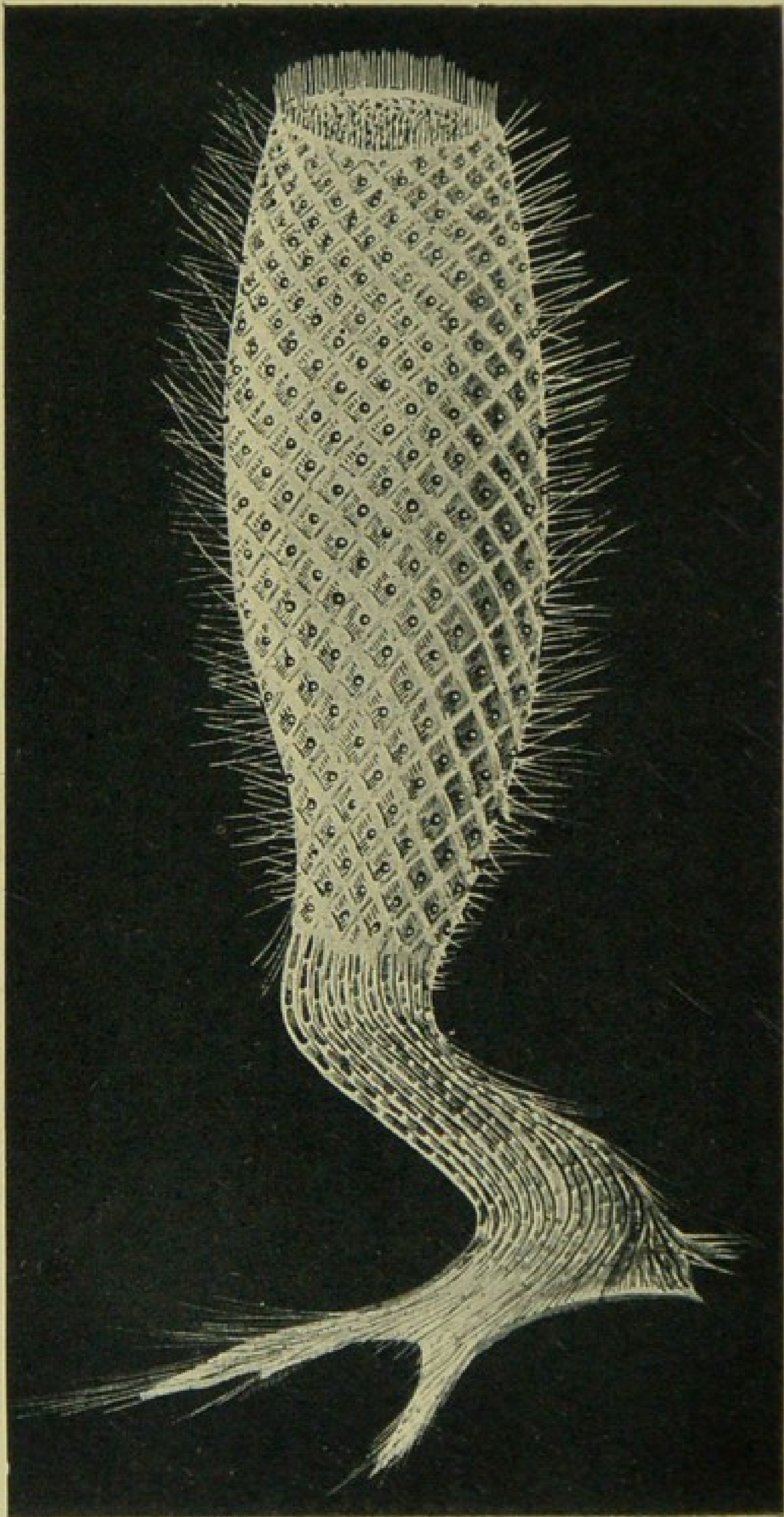

Fig. 3.—Euplectella suberea.

CHAPTER II

HOW TO BEGIN

It may be asked: 'Where are these hidden beauties of Nature to be found?' They are almost everywhere. It would be more difficult to point out where they are not to be found than to show where they are in abundance. They can be found in the fields and woods, in ponds and ditches, on the mountain and plain, in the valley and the cliff, at the sea-side, on the surfaces and floors of all oceans, seas, lakes, rivers, and streams in all parts of the world—hot, temperate, or cold.

To aid our own exertions, the microscope will be the great and the chief accessory, though many of the objects described are visible without that instrument. It will be well, however, to remove at once the belief that an expensive microscope is a necessity at the outset. As the wonders of the heavens and important discoveries therein do not always need a powerful and expensive telescope—for recently a gentleman, using a pocket telescope, discovered a comet, which now bears his name, and which was overlooked in observatories furnished with magnificent appliances—so is it with regard to the beauties of Nature. Numberless objects, affording exhaustless gratification, may be studied, and that successfully, with very inexpensive magnifiers. It is a significant fact, that a large number of those persons who look into even ordinary microscopes for the first time and see marvellous objects developed in unexpected beauty, become enraptured, and often strain every point, if need be, in order to become purchasers of the instrument which has the power of revealing such wonders. Hence it is that there are thousands of microscopes in use now for the one of former days. It will be a good time for the young people of England when the microscope is looked upon as a necessity in the home, for it will make the family circle more attractive, and will supply plenty of employment for the winter evenings.

Our knowledge of Nature, meagre as it is, would be much more defective were it not for the microscope. Many of the hidden beauties we are to notice in these pages are on the borderland of our vision, and some are too small to be seen with unassisted sight. Human vision is limited in several directions, notably in our power to measure distances on the one hand, and to see minute things on the other. A compensating power is graciously given to us, and that power we may call *intelligence.* By it we can think out, and invent, and construct a telescope that will add a thousand-fold to the range of our vision as regards distance. And we are enabled by this same intelligence —the gift of our good Creator—to construct a microscope that will add more than a thousand-fold to our power of viewing the minute things of creation.

Yet, with our most powerful telescopes, we fail, apparently, to alter the distance between us and the nearest fixed stars ; and with our microscopes we fail to exhaust the design and the symmetry in a humble diatom (see chapter on 'Diatoms'). It is perfectly clear, then, that the powers of the eye and of the mind were intended to be used intelligently. And how can they be put to a better purpose than in searching for those wonders which God has created, and in which He has shown such infinite skill and power? And are we not also in duty bound to make known to others these evidences of the creative power of

God, so that He may be glorified in His works?

In addition to the microscope, other requisites will help to unfold the hidden beauties of Nature. But these are of a less expensive character. For cliff or quarry work, a good hammer, a strong bag, a penknife, and a cheap pocket lens will suffice (see chapter on 'A Seaside Ramble'). Some of the most lovely fossil sponges I ever saw were taken from a block of chalk with a penknife and patiently cleaned, and the textures of surpassing beauty exposed to view with the aid of a brush. The treasures of our museums of Natural History are a standing argument in favour of making collections for purposes of study, and are, in the main, the result of individual effort. In our rambles we may be able to augment even such collections.

If any boy should be induced to follow out some special course of Natural History study, let him bear in mind that his hobbies ought not to inconvenience other people. He must keep his specimens in a proper place. If he should be untidy, and leave the various objects lying about in the drawing-room, he will never make a careful collector. A tidy boy will become a tidy man. Whatever you collect you should read about in the best books on the subject you can get hold of, and, if possible, you should make your own notes about them in a special manuscript book. A certain botanist carefully enters in his diary the dates on which he sees the several orchids in flower, and it is surprising how regularly they respond to the dates of previous years. If I ask him to come in search of some particular bloom, he will refer to his book, and if I am premature in my request, he will quietly reply, 'You will not find it before such and such a day.'

The entomologist, too, is equally careful to enter the dates of the capture of insects, so that he may refer to the entries in future seasons. Some moths are so punctual that they come out only at certain fixed hours, as regularly as clockwork, and it is useless to seek them at other times.

If you grow keen in the pursuit of such objects as are described in these pages, you will find your walks much more enjoyable, and your holiday excursions more full of pleasure than they can ever be to any ordinary observer of Nature.

To help young people to use their eyes intelligently, the Dover Natural History and Antiquarian Society adopts a plan that is well worth imitation in every town in England. The president and the vice-president organise meetings for young people, at which are given brief scientific demonstrations of ten minutes' duration. Different topics are dealt with, in simple language, by different lecturers; and as each lecturer makes his subject as attractive as possible, the meetings are most enjoyable, and doubtless productive of much good.

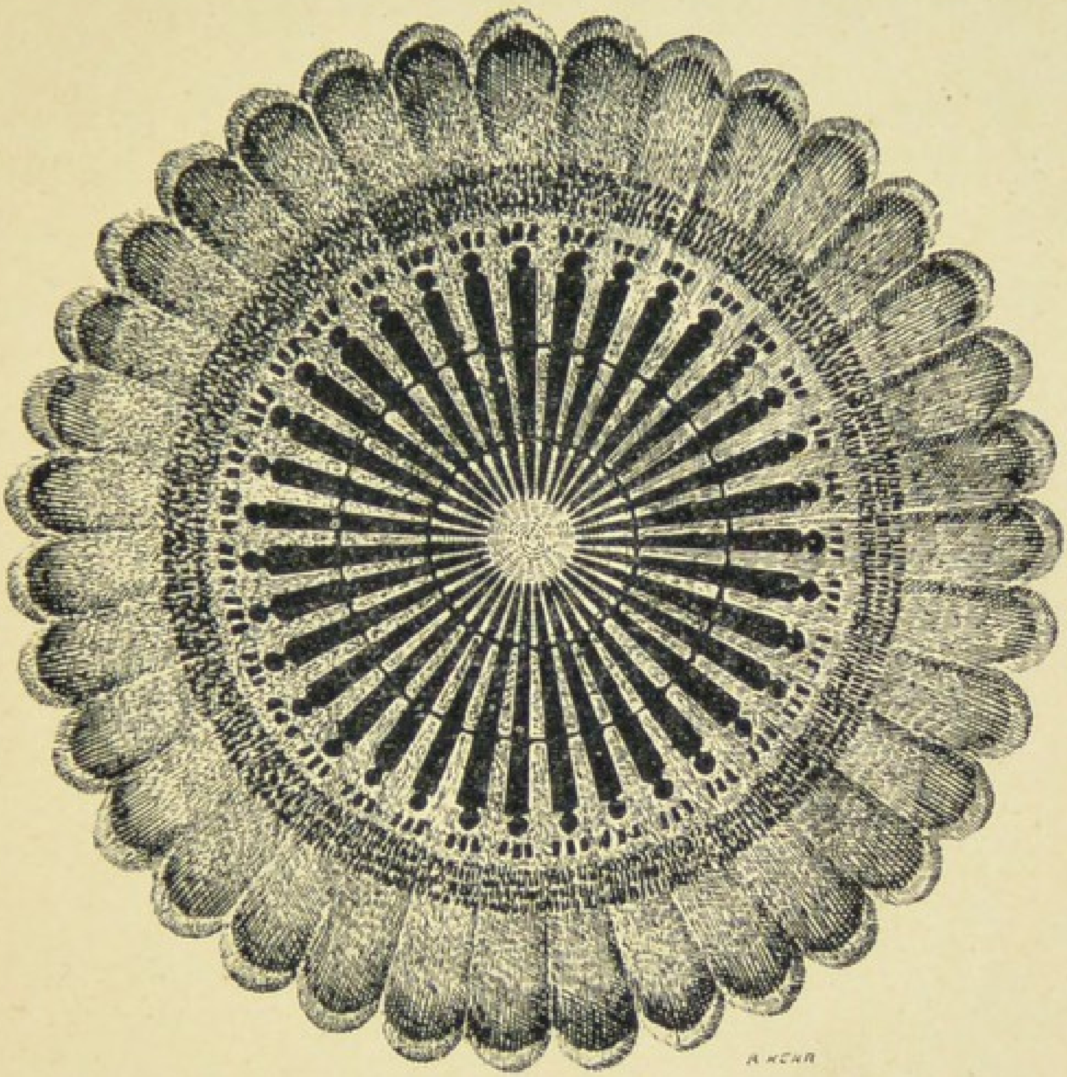

Fig. 4.—A thin section of the Spike of a Sea-Urchin, $\frac{1}{15}$th of an inch in diameter.

CHAPTER III

THE SEA-URCHIN

THE Colosseum at Rome, when in its finished condition, and ready for the inauguration of spectacular cruelties, was, no doubt, a magnificent piece of workmanship. Its ruins at the present moment are sufficient to show this. But on referring to Nature, we can readily find an object which will eclipse the symmetry of the Colosseum, and, at the same time, occupy but the tenth of an inch in diameter, or even less. The sea beach will supply us with any number of such objects. We will select one. It is the spine or spike of the sea-urchin. Many of the spines are no thicker than a brass pin. The echinus is a creature nearly related to the star-fish, and is covered with spikes which somewhat resemble those of the hedge-hog. Take one of these spikes, cut it across with a sharp knife, or better still, with a razor, and then cut a thin shaving transversely, and place it on a slip of glass. Look at it with the microscope. If you know anything of photography, photograph it through the microscope. Thereby you will obtain a very much enlarged picture of it, which if put into a lantern may be shown on a screen 12 or 15 ft. in diameter. Notwithstanding the tremendous enlargement from one-tenth of an inch up to several feet, the beauty of this object always commands general and unstinted admiration.

Different classes of sea-urchins have different kinds of spikes, but all show wonderful sections. Figures 1 and 2 may suggest hints to designers

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in lace, in wall-papers, in linoleum, or may be copied as centre pieces for ceilings, for patterns

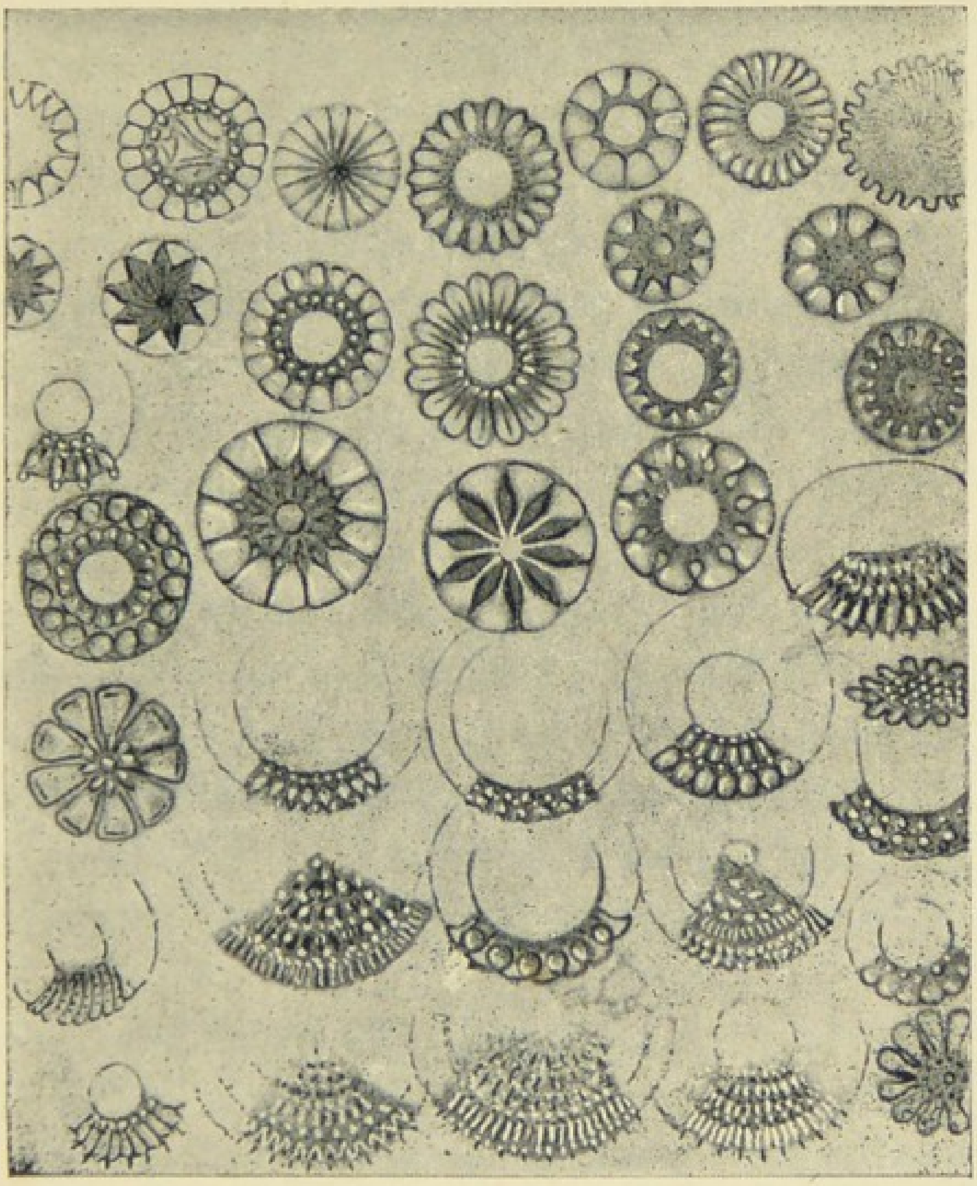

Fig. 5.—Transverse sections of Spikes of Sea-Urchins. Enlarged.

for mosaic work, or for the stone mullions of end windows in churches. The landscape artist tells his pupils to go to Nature if they would excel ; so, too, it may be said to the industrial designer, take your ideas from the hidden beauties in the surrounding creation, and you will find perfection at your command.

Apart from the spines to which we have referred, the box or case of the echinus, deprived of spikes and thoroughly washed on both sides, is a very beautiful structure. It consists of a multitude of plates beautifully fitted together, and arranged to grow larger as the creature grows. Considering the thinness of the plates and the extremely light weight of the structure, there are few objects of its size that will stand equal strain. Every part of the echinus will bear the closest examination, and will prove sufficient for study for a long time. The people along the shores of the Mediterranean eat the contents of these echinus boxes. They are sold in the markets with other products of the sea.

Professor A. Agassiz tells us in his Report on the Echinoidea, or sea-urchin tribe, that there are 2,300 known species of fossil and recent echinids. His report contains 321 pages of descriptive matter in addition to 45 plates of illustrations. This will show the extensive character of this one department of Natural History. Some members of this vast family are always to be found washed up on all sea shores from the poles to the equator. We ought, therefore, to have little difficulty in procuring specimens for examination. In the fossilized state they may be picked up in any district where chalk is the prevailing rock. Frequently we find them on the roads with the flints, doing duty as road material. Going back to still earlier geological formations, we find splendidly preserved representations in the Jurassic rocks —the pygaster being possibly the best known.

All the sea-urchins have an arrangement of tubes and canals, known as the water-vascular system, through which water is conveyed to all parts of their organization. Starfishes and kindred creatures are similarly endowed. A hidden beauty connected with most members of this family is the 'madrepore plate' or 'madreporite.' Notwithstanding its name, it has nothing to do with coral structure. To see this beautiful object to perfection it will be necessary to take up a sea-egg or sea-urchin, or better still a starfish, and with a pocket magnifier to examine the upper or dorsal side of the creature, when a white spot will be observed near the centre. This will be found to bear all the appearances of a piece of white coral. The sea water is said to be admitted through this sieve, the entrance to a branch tube which communicates with the water-canal system. Its supposed duty is to keep out particles of sand and other small objects that would interfere with the creature's comfort. Thus in the madrepore plate utility is combined with hidden beauty.

A student possessing a microscope and living near any sea shore will always have facilities for studying some representative of the great family of sea-urchins. In addition to cutting sections of the spikes for the purpose of seeing the incomparable designs displayed, as already alluded to, if a portion of a spike be examined while the creature is alive, the cilia may be seen in full activity. Cilia at all times require high magnifying powers, but their wave-like motions are well worth extra painstaking. If tiny echini be taken when no larger than boot-buttons, and carefully kept in seawater, they will live for many months, and will always be available for examination. No specimen is equal to the living one for study. As regards the organs known as pedicellariæ, no true idea of their movements can be realized except in the living specimens. Two friends living at Dover kept young sea-urchins for a great length of time. Repeatedly I have seen them under the microscope, and on more than one occasion they proved to be great sources of at-

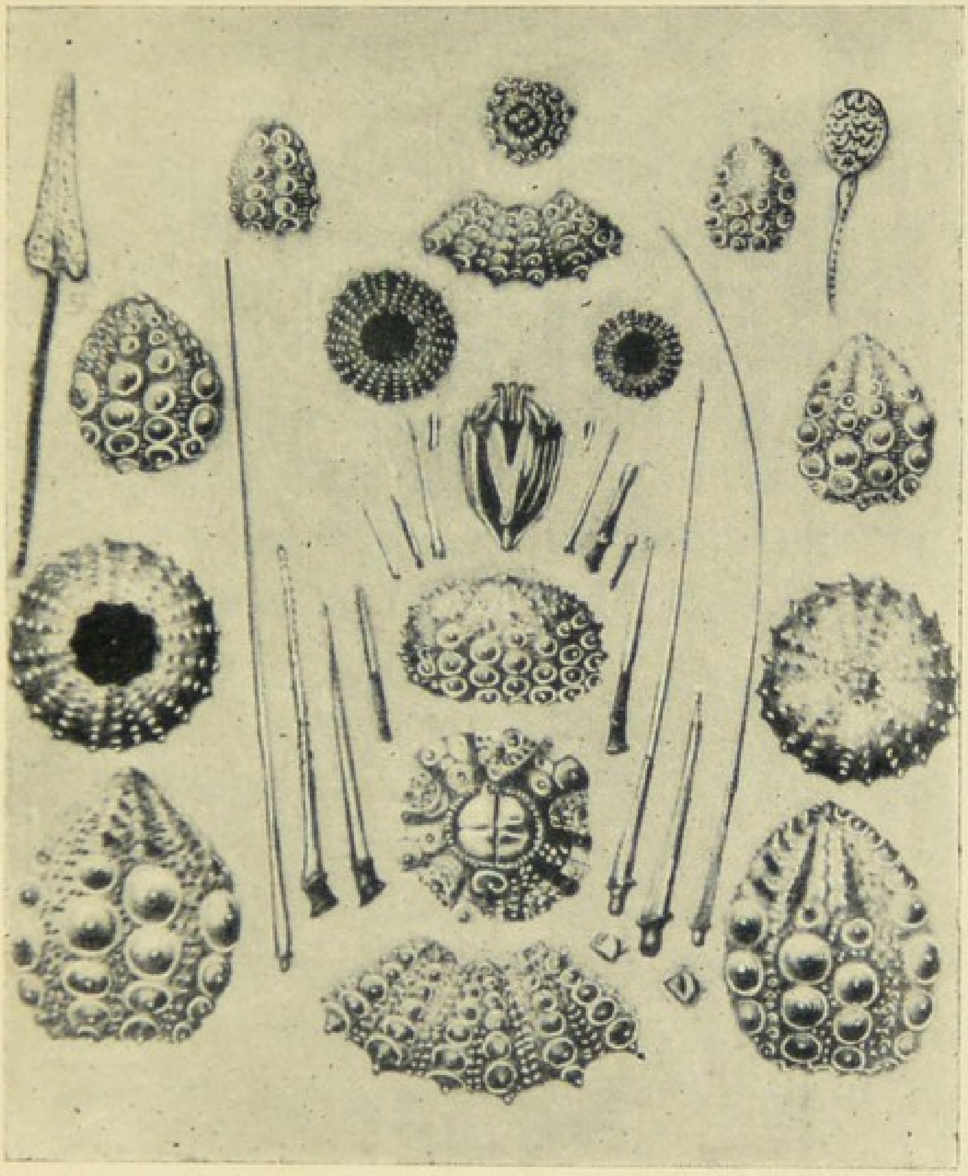

Fig. 6.—Parts of Sea-Urchin. Reduced.

traction at public gatherings of the local Natural History Society.

Again, when the specimens are dead, if we crush a portion of one of the spikes into small fragments, we shall see the transparent calcareous substance of which it consists, and the secret of the remarkable strength combined with lightness which characterises all spikes or spines of echinoderms. Each fragment is joined to its fellow in a wonderful manner, and a system of communications pervades not only the spike but every portion of the solid parts of all members of the sea-urchin group. This microscopic structure of these marine organisms forms a most fascinating branch of study to all who are at all acquainted with it. The minute structure of the shell is the same throughout, forming a sort of network of carbonate of lime with a very small admixture of animal matter. The shell itself consists of geometrically arranged plates, joined together with marvellous exactness, and covered with about 4,000 spikes, every one of which is beautiful to the minutest detail. Mr. Saville Kent tells us, that in many of the Australian varieties these spikes are so fine that his hand was pierced with them before he was aware he had approached so closely to them. Some spikes are club-shaped, while others are three-sided.

As regards the pedicellariæ, they are not separate individuals, but form essential parts of the sea-urchin. Müller, the famous Danish zoologist, thought they were parasitic animals. This is not to be wondered at, for there are

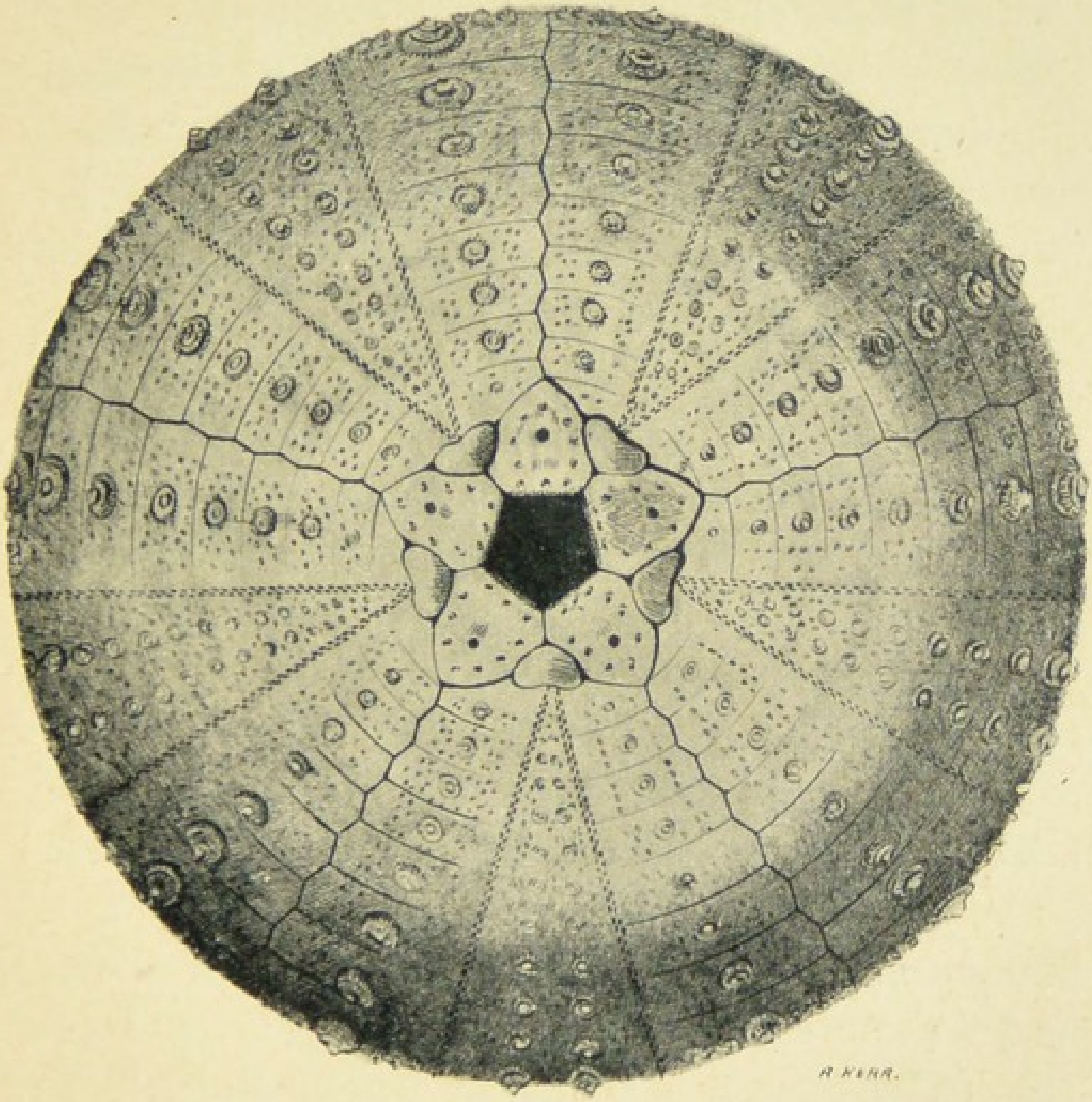

Fig. 7.—The Echinus, or Sea-Urchin. The Spikes removed.

few more mysterious organisms in that portion of marine life which is known to zoologists. To this day there is considerable doubt as to the services they render to the urchin. It consists of a fleshy stem, perforated by a calcareous shaft, which rests on the skin of the creature, and of a head which has three divisions, and which bears close resemblance to the head of a bird. The edges of these pieces, which open and shut, are provided with teeth. The whole structure is clothed with transparent flesh, and the head, besides opening and shutting, can move to either side. All the movements seem to be voluntary. These supposed voluntary motions must have caused Müller to believe them to be separate creatures parasitic upon the echinus. Their minute structural details are marvellous. When alive, the action of the pedicellariæ creates great amusement. They are charming objects for microscopical examination, and as their duties are not fully known, they arouse the interest of all who observe them. The late P. H. Gosse, F.R.S., suggested 'that they are intended to seize minute animals, and to hold them till they die and decompose, as baits to attract clouds of Infusoria, which, multiplying in the vicinity of the urchin, may afford it an abundant supply of food.'

Hundreds of other points of interest in the structure and life history of the echinus might be mentioned; but as there are special monographs written about this creature, which, however elaborate, are by no means exhaustive, we feel we can only point out to beginners the great importance attached by marine zoologists to the ordinary echinus. Ordinary because of its every-day occurrence, but far from ordinary as regards its marvellous structure.

CHAPTER IV

NATURE'S FIREWORKS

NUMEROUS and varied as the fireworks made by art may be, they are eclipsed by the displays produced in Nature. This would be apparent in a moment if we were to consider the aurora, the meteors and other majestic and luminous effects, which take place in the canopy over our heads. But this is not our intention, neither do we include the large family of insects, called the Lampyridæ,—the shiners,—which belong to the American continent, and which have representatives in Europe, as in the case of the glow-worm. The displays to which we now draw special attention are all marine.

In certain oceans and seas, in calm weather, when the nights are dark, the wake of the passing ship resembles a path of oscillating gold, increasing in brilliancy until it glistens in whiteness. The contrast with the surrounding black waters becomes most impressive. The boatman puts off from the shore, and as he dips his oars and lifts them up the dripping waters sparkle as if illuminated by thousands of microscopic arc-lamps, while the prow of his boat cuts its way through liquid brilliants. A gentle

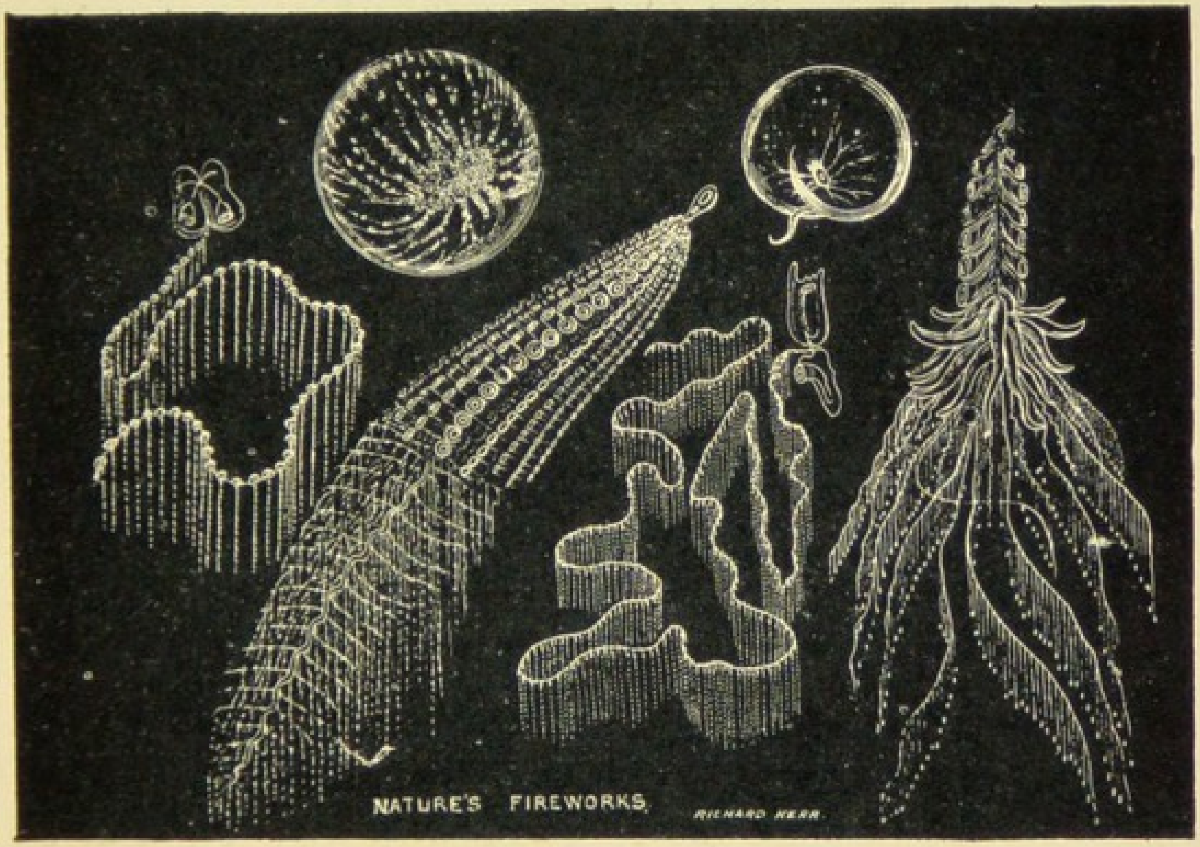

Fig. 8.—Some of Nature's Fireworks.
(Adapted from Voght's *Syphonophores de la Mer de Nice.*)

ripple is sufficient at certain times to cause the luminosity to appear, but when the sea is absolutely smooth there is no observable display.

Now the principal factor in this wonderful effect is a minute organism, known as Noctiluca miliaris (thousands of night lights), first described by Rigaut. The jelly-fishes, sea-urchins, crustaceans, sea-anemones, and most marine creatures, also have this power of emitting light. The Noctiluca miliaris is a creature a little smaller than the remarkable plant, Volvox globator of fresh-water ponds, noticed in chapter XVI., and is about the sixtieth of an inch in diameter. It possesses a whip-like tail or lash, which, lashing the water, serves as an organ of locomotion. Myriads of these creatures form as it were a thin sheet of phosphorescence spread over the sea.

Imagination is baffled in trying to form any idea of the number of living representatives of even this one family of life's children. Collectively they produce a luminosity that is both pleasing and useful, but individually they are hidden from us, and we should know but little about them were it not for the microscope. The little we do know does not include a knowledge of the secret whereby the organism produces its flash of light. It is surprising how much the powers possessed by a very tiny creature can puzzle a philosopher. We can with the microscope examine these and other phosphorescent creatures, and we can ascertain the exact point where the illuminating power is located, whenever that power is limited to certain parts of the creature's structure, but we cannot point out the manner in which the real agency at work produces such a pleasing result. We find, as it were, the microscopic room where the miniature electric light is generated, but the workings of Nature's electrical machine baffle our utmost efforts.

Several experiments have been made by Panceri, the skilled Italian chemist, and others, with a view to the discovery of the secret. Results have been produced, by experiments with oxygen and alkaline reaction, which resemble the phosphorescent energy of the creature. But in all such laboratory experiments for generating light an amount of heat was developed, denoting a process of oxidation, and hence burning. Whereas the most delicate tests that have been applied to those creatures which have the greatest power of emitting light, have failed to detect any increase in temperature. Panceri made many experiments upon the rock-boring pholas of the Mediterranean, and to make his researches more accurate, he used the electric thermo-pile, which could register far more accurately than any thermometer the least increase in temperature. But he failed to detect any change during the emission of light. We are compelled to admit that though we may produce a light which has the appearance of that produced by the hosts of creatures in the oceans, yet it is quite different, and we have, as yet, failed to find out the process by which even small creatures emit their remarkable glow.

It was thought by Mary Somerville that the luminous effect produced by marine creatures might be the result of involuntary nervous contraction, and if so, 'then the light must be electric.' Darwin, in his *Voyage of the Beagle*, says: 'While sailing a little south of the Plata on one very dark night, the sea presented a wonderful and very beautiful spectacle. There was a fresh breeze, and every part of the surface which during the day is seen as foam, now glowed with a pale light. The vessel drove before her bows two billows of liquid phosphorus, and in her wake she was followed by a milky train. I am inclined to consider that the phosphorescence is the result of the decomposition of the organic particles, by which process (one is tempted almost to call it a kind of respiration) the ocean becomes purified.'

In many creatures this power to emit light is a means of defence, while in some it acts as a lamp of attraction. The poison threads of the jelly-fish would prove to be very disagreeable food for fishes, hence Mr. Chisholm conjectures, and with very good reason, that in being luminous they act as a danger signal to others, while the luminosity affords security to themselves. Several of our great biologists are agreed that while this luminosity of marine creatures serves a grand purpose in beautifying the ocean surface at night, it renders a more serviceable duty in that it illumines the deep abysmal waters away down where the rays of the sun can never penetrate; but for this the vast ocean depths would remain in utter darkness.

Whether photographs can be taken with this light remains to be proved, but with the strides photography is making, we may expect to see the floors of oceans and the denizens of the deep photographed in all their natural conditions. These are not times in which to say such achievements are an impossibility.

In Great Britain and Ireland we can hardly realize the power of this luminosity, as it is never at its best around our coasts; but in the Gulf of Mexico the effect is splendid.

Writers who have spent a great deal of time at sea, agree in saying that the light emitted by marine forms of life is at times so powerful as to permit books to be read with facility, and even to illuminate the sails of the vessels. Not unfrequently, on capturing specimens, they found the chief agent to be a creature, about four inches in length and an inch and a half in circumference, known as pyrosoma. It is tube-shaped. When several of them were taken up in a supply of sea water they withheld their light, but when the water was shaken all became brilliantly illuminated. The surface of the pyrosoma appears to be studded with brilliants. On other occasions the creatures that emitted the light were microscopic noctilucæ, while medusæ play a prominent part in this kind of illumination in all seas and oceans.

That the jelly-fishes emit light in a very marked degree will be evident from the experiences of Prof. A. Agassiz, related in the *Voyage of the Blake*: 'As we lift our net from the water, heavy rills of molten metal seem to flow down its sides and collect in a glowing mass at the bottom. The jelly-fishes, sparkling and brilliant in the sunshine, have a still lovelier light of their own at night. They send out a greenish golden light, as lustrous as that of the brightest glow-worm, and on a calm summer night the water, if you but dip your hand into it, breaks into shining drops beneath your touch. All this phosphorescence is seen to greatest advantage on a dark night, when the motion of the vessel sets the sea on fire around one. At such times there is something wild and weird in the whole scene, which at once fascinates and appals the imagination ; one seems to be rocking above a volcano, for the sea is intensely black, except where fitful flashes or broad waves of light break from the water under the motion of the vessel. The sea may be black as ink, with the crests of the waves breaking heavily, and surrounding one with walls of fire in all directions.'

The late P. H. Gosse, F.R.S., in his *Evenings at the Microscope*, says in his description of the jelly-fish Thaumantias : 'The outline is fringed with about fifty short and slender tentacles, each of which springs from a fleshy bulb, in which is set a speck of deep purple. These collections of coloured granules, which I have already explained to be rudimentary eyes, have a very charming effect, and give a beautiful appearance to the little creature, as if its translucent crystalline head were encircled with a coronet of gems. . . . Come with me, and I will carry the glass containing our little Thaumantias into the next room. You need not bring the candle, or what I am going to show you will be quite invisible. Take hold of this pencil, and having felt for the glass, disturb the water with it. Ha! what a circle of tiny lamps flash out! You struck the body of Thaumantias with the pencil, and instantly under the stimulus of alarm, every purple eye became a phosphoric flame.'

Any one who has sufficient courage to walk on the seaweed along the seashore at night, will frequently see the rays of light shooting out in all directions like so many displays of fireworks, and not unfrequently will there appear the passing medusæ, gracefully moving like so many illuminated tiny umbrellas. As the water is disturbed by the passing boat it becomes illuminated by the microscopic forms of life. Miss Pratt vividly pictures the displays of Nature's fireworks: 'Down below the surface these jellies seem like balls of gold or silver, sometimes, as in the girdle of Venus of the Mediterranean, appearing like a riband of flame several feet long; or, as in the yet more luminous pyrosoma, enabling the voyager to read by their light as he stands by the cabin window of the ship. Some of the larger species are described as having the resemblance to white-hot shot, visible at some depth beneath the surface.'

CHAPTER V

THE EUPLECTELLA, OR GLASS SPONGE

THE Euplectella receives its name from two Greek words which mean 'well woven.' The waters of the ocean supply us with this hidden beauty. For two or three reasons we may call it hidden. Its home is at the bottom of the ocean or sea. There it is anchored in a muddy deposit. Even when brought to the surface, that part of it which we wish to notice is embedded in a very uninviting-looking covering—the flesh or sarcode of the creature.

The creature is a sponge, but not that whose leathery skeleton we use in the bathroom. The first specimen which found its way to England 'exchanged hands several times for £30.' Good 'glass sponges' can now be purchased for three shillings. One variety was pronounced by the naturalist Ehrenberg to be a specimen of Japanese art, and was placed in the cabinet of Oriental curios. This can hardly be wondered at when one examines the 'beau-

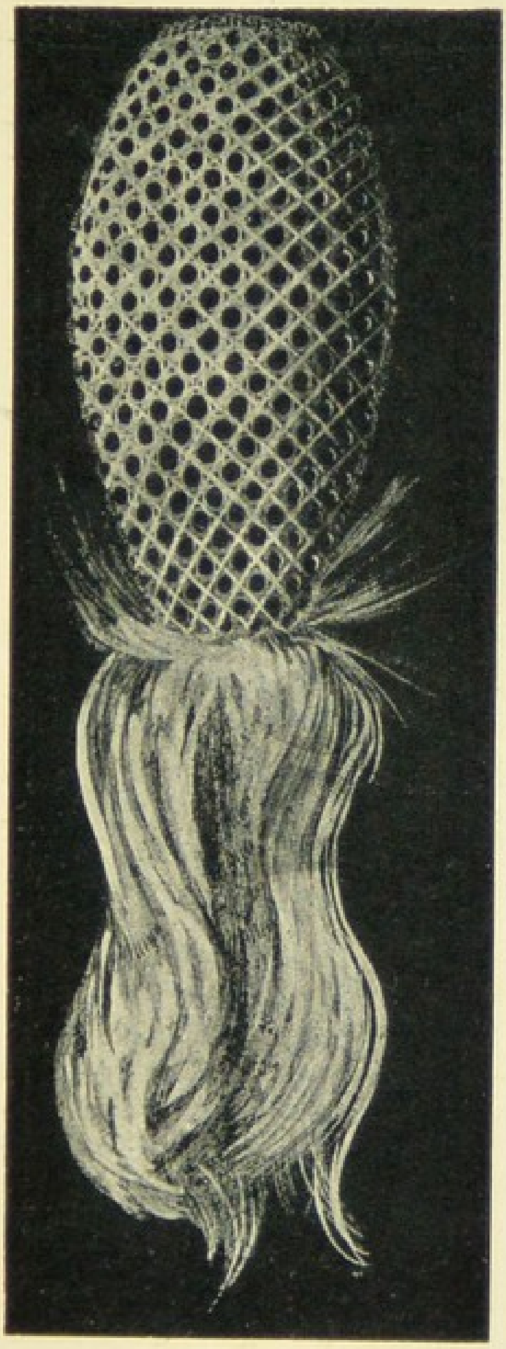

Fig. 9.—Euplectella cucumer.
(*S. Kensington Museum.*)

tifully woven' texture of any one of the series of cornucopia-shaped samples in any of the London naturalists' shops, or better still, the

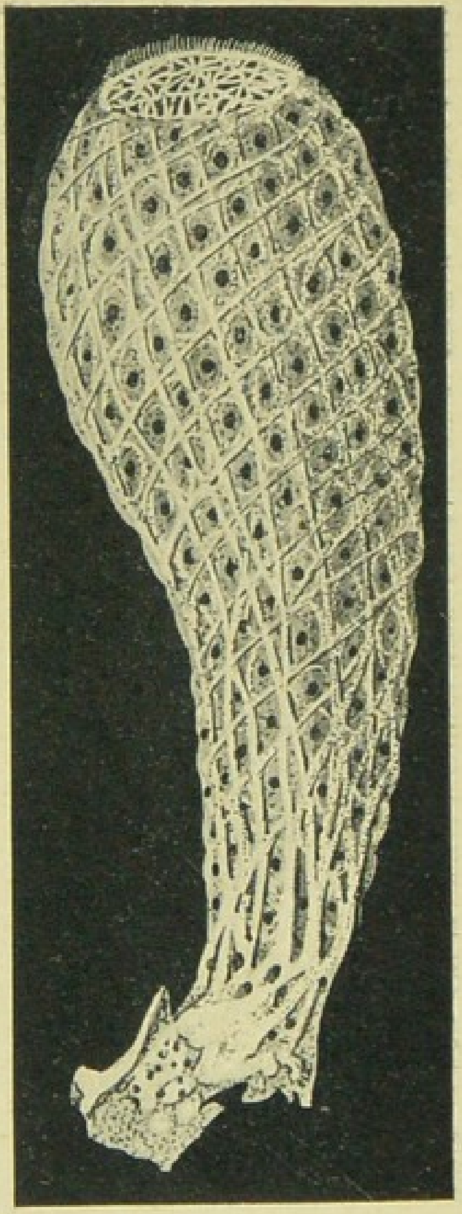

Fig. 10.—Regadella Phœnix.
(*A. Agassiz.*)

collection in the Coral Room of the Natural History Museum at Kensington.

Another variety led to a great discussion among the English authorities on corals and sponges, and were it not for the microscope and Professor Lovén of Christiania, its true nature would have remained in obscurity for a greater length of time.

The euplectella is such a favourite with naturalists that they have called it by the complimentary name 'Venus's flower basket.' A small portion of the brown, leathery, shrivelled-up flesh, or sarcode, which was found attached to the skeleton, was examined under the microscope, and it was discovered to contain a vast quantity of spicules resembling tridents, spears, anchors, harpoons, etc., all consisting of flint, and entirely too small to be detected with unassisted eyesight. Thus the microscope, which discriminates so unerringly between the works of Nature and those of art, did not hesitate to pronounce the verdict entirely in favour of Nature. Man could not make such wonderful spicules, so the naturalist concluded that these formed a kind of chain armour which kept the living sarcode together, and that the creature, however unlike the sponge of commerce, must belong to the great family of sponges. Thus the hidden beauties of Nature, as regards this creature, would never have been seen but for the microscope.

The late Lady Brassey brought home a

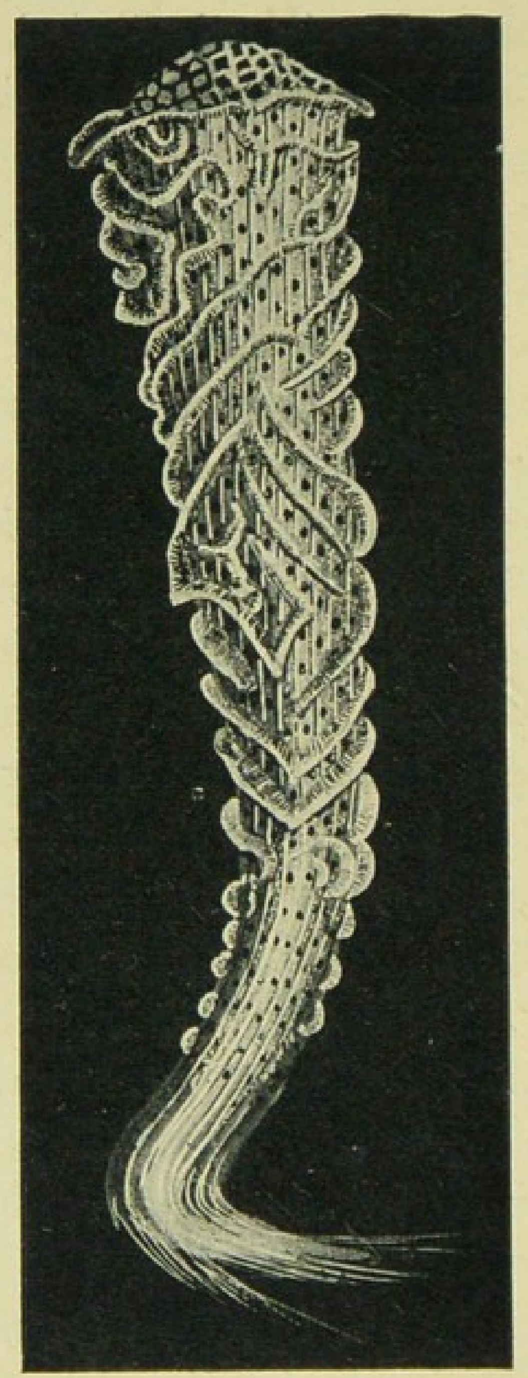

Fig. 11.—Euplectella aspergillum.

large quantity of these lovely objects from the Eastern Archipelago. The naturalists on board the Challenger dredged specimens up from the Atlantic and other ocean floors. The naturalists on board the Blake added several new specimens to those already known, and now various forms of the euplectella are to be seen in every museum.

Different methods are adopted for bringing up these curious sponges from the deep; the most primitive, and that which was used by a friend, for many years in the neighbourhood of Northern Borneo and the Philippine Islands, is as follows: When the waters were perfectly quiet, my friend and his man would take their boat and a supply of exceedingly fine line and a few small fish-hooks with a lead attached. One would row very slowly, while the other would let down the line with the hook. This would drag along until an obstacle was reached, then a gentle pull generally ended in the capture of the euplectella. Its home is among the mud and slimy matter at the bottom of the ocean, hence its first appearance, coated as it is with its sarcode, which forms the body proper of the animal, is a most unattractive one.

Most creatures look better with their skeletons covered. Even man does. Not so with the 'Venus's flower-basket.' Its skeleton is its lovely part. If one could imagine such a thing as dirty blanc-mange or starch, into which the beautiful skeleton was dipped and drawn out again, a pretty good illustration of the living creature would be pictured.

The fleshy substance, in which are all the lovely harpoons, tridents, spears, etc., known as spicules, must be washed away and the 'glass sponge' bleached. It is then fit to take its place in our cabinets of natural history specimens, and will rank second to none in interesting features and loveliness.

But to go back for a moment to the fishermen. Our friend has hooked a sponge, but it has too firm a hold by its long 'glass' threads, and it refuses to come up. The hook is bound to break a small piece away, hence a rent is occasioned. Here comes in the extraordinary part of the story, of the certainty of which, however, I have no doubt whatever. The next year they dredge over the same piece of water, and if they draw up the sponge they missed on the previous expedition, they will find the hole (formerly made by the hook) darned up most beautifully. Such specimens fetch a much higher price in the English market. John Chinaman knows this, and as nearly every sponge must of necessity be damaged somewhat, owing to the difficulty of taking out the hook when the sponge is 'landed,' he takes off some of the threads from the attaching end, which are four or five inches long (often more), and with these he cleverly darns up the holes in every sponge he can lay his hands on, and by passing them off as the work of the 'other animal,' he obtains the extra price for them. Latterly naturalists are able to detect the fraud, for John's work is not nearly so deftly done as that of the 'glass sponge' creature.

The euplectella has been found in all oceans. Some varieties are limited to certain localities, while others are cosmopolitan.

It would be hardly right to dismiss this subject without noticing two other points. First with regard to the sarcode or flesh of the creature. It was thought to be granular jelly, but on closer scrutiny it was found to be tiny animal cells, each possessed of a single lash or cilium. The sarcode has the power of appropriating from the incurrent streams of water not only the air and food it requires, but also the mineral or other matter it needs for the rearing up of its framework.

It is a most remarkable fact that however carefully the sarcode may be chemically analysed, that of all classes of sponges is the same, the leathery, the chalky, and the flinty, no difference can be detected between their respective sarcodes. They are invariably alike, yet there is a vast difference in the *work* accomplished by the sarcodes of the three orders. One sarcode produces a leathery or keratose skeleton, another a calcareous or chalky skeleton, and the third a silicious or flinty skeleton.

The power by which the sarcodes of these three orders secrete and deposit their respective skeletons depends upon some mysterious principle which refuses to be discovered by chemistry or the microscope. We are forced into the belief that some vital principle is at work which is not mere chemical action. This is life, and we must recognise a power and a wisdom exerting their influence in ordering the line of life in these three sarcodes—the sources of that power and wisdom being God, the author and the giver of life.

For the sake of seeing the splendid specimens of 'Venus's flower baskets' alone, it would repay any one interested in this branch of Natural History to spend an hour or two in front of the case of euplectellæ in the South Kensington Museum. The case forms one of the boundaries of the coral department. Definitions

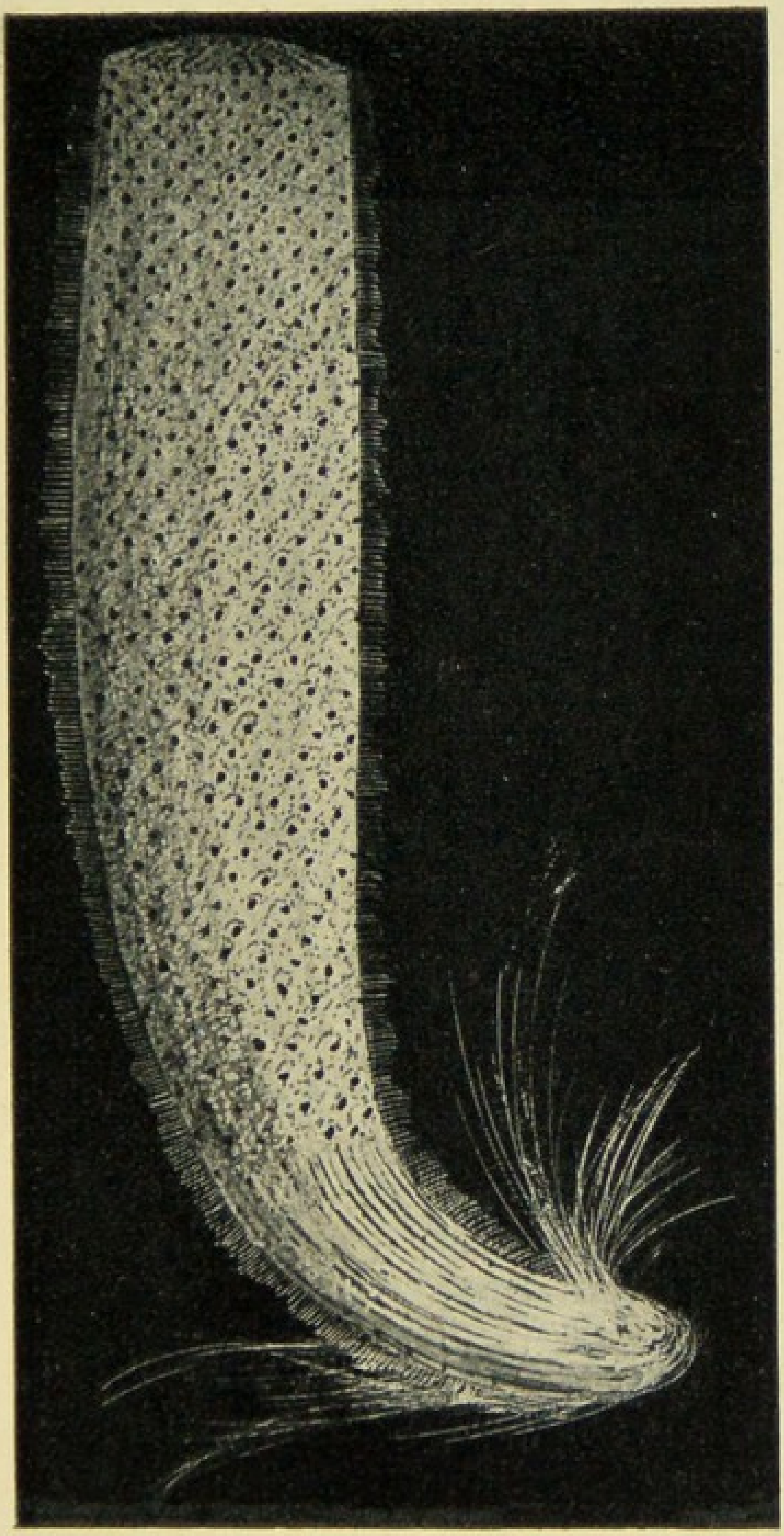

Fig. 12.—Euplectella Jovis.

(*A. Agassiz.*)

and descriptions, however accurately scientific, can help us but little to understand what these lovely objects are like in shape, texture, and lightness. We must actually see them for ourselves in order to realize their matchless attractiveness. They seem to occupy a place in Nature far removed from the generality of marine forms of life. Yet they have a definite position along with the sponge family. The experienced zoologist, Professor H. Alleyne Nicholson, says: 'The "Venus's flower basket," without any exception, is one of the most exquisite of all organic structures known to us.'

There are in the glass case to which I have referred sponges that look like extra finely worked birds' nests enveloped in lace-like covers, cornucopia-shaped baskets and vases, and several glass-rope sponges of the Hyalonema family. The Hyalonema possesses a flowing mass of transparent flinty threads, resembling spun glass. These filaments are used for attaching the sponge to the bottom of the sea. They are much longer than those of euplectella. Fairly good specimens can be bought for half a guinea, but the best glass-rope sponges fetch many pounds. These particular forms are dredged up in the Pacific, off the coast of Japan.

The artistic proportions, the harmonious symmetry, and the elegant outlines of the 'Venus's flower basket' cannot be the result of accident or coincidences. How can the thousands of cells arrange among themselves when certain flinty rods are to take this or that direction? Is there a general agreement among all the microscopic particles of sarcode as to how their wonderfully latticed framework is to be a certain width, height and curvature? Have they the power of counting? For a certain number of glass bars must be across here and another number there, else this 'basket' would be unlike that which is growing a few feet away. If not, if there be no understood agreement between all the minute parts of the organism, there must be some vital principle which controls every movement in the creature's life, otherwise the structure would be without beauty and symmetry. 'It is growth,' we are told; but growth depends upon life. What is life, and who gives it?

These questions apply with equal force to the growth of the sweet-scented flower, to the beautiful bird, the gauzy-winged butterfly, and more especially to ourselves. For of all the Creator's works, man seems in his organization to be the culmination of all wonders. And if that pervading influence we call life, and other influences imparted to man alone—not shared by jelly-speck, by flower, or by bird—be not permitted to have their full scope and action in our lives, how can we grow up to the pattern to which our Creator desires us to aspire ?

We must not imagine that only an occasional specimen of the glass sponge tribe has been found, nor that they are limited to the floor of any particular ocean or sea. Before scientific explorers had proper apparatus for deep-sea dredging, only a comparative few were known. But since the days of the 'Challenger Expedition' vast quantities have been brought up from all the oceans, and from several seas and bays. As an example, we have the authority of Prof. A. Agassiz for the statement that sponges of various kinds occur in abundance off the coast of Florida, and that 'the trawl would constantly come up filled with masses of both silicious and calcareous sponges.'

Directly connected with this subject arises the question of the supply of silica (flinty matter) for spicules and for the skeletons of the sponges ; for the ordinary ocean water at the surface does not show any great proportion of this element. Another question presents itself quite as forcibly: what becomes of the sarcode or flesh of these hosts of sponges and of other forms of life which are in the oceans when the creatures die? In his *Voyage of the Blake*, Prof. A. Agassiz says: 'Judging from my own experience, we must unquestionably refer this supply of silica to the large fields of deep-sea silicious sponges, which when dead and decomposed supply the spicules found scattered all through the calcareous mass of the deep-sea globigerina ooze. These silicious sponges are often found in great numbers, as in the globigerina ooze off Santa Cruz, for instance, where numerous specimens of an interesting new pheronema were dredged, as many as ten to fifteen in a single haul. The whole mass of the mud was so thoroughly impregnated with spicules and with sponge sarcode as to be sticky and viscid. More than once the dredge must have plunged headlong into one of the ubiquitous sponge beds—the glairy mass like white of egg, with a multitude of spicules distributed like hair in mortar throughout the mud.'

This, as well as the analyses ot the bottoms, plainly shows that the amorphous substance giving to the mud its viscidity is not produced by sulphate of lime in a flocculent state, but is due to the presence of a mass of decomposed protoplasm—*the remnants of all the animal life which has accumulated for ages upon the bed of the ocean.* This is slowly used again by living animals, and kept from putrefaction and decay by being preserved, in the excess of carbonic acid, in regions where no rapid oxidation takes place, either from currents, or waves, or from atmospheric influences.

An immense amount of silica must find its way into the sea, and be immediately dissolved by the excess of carbonic acid found near the bottom, while only a portion of the calcareous mud can be taken up in solution. Hence this silica is at once placed under the most favourable conditions for resorption by organisms living upon the layer of protoplasmic substance which covers the bottom of the ocean, into which the silica has been received. As Wallich and others have most distinctly proved, this protoplasmic layer, where it exists, is the *product* of the organic life, and not its source.

This gives us an insight into the conditions prevailing on portions of ocean floors not affected by tides and currents, and accounts for the large quantities of glass sponges and their supplies of silica.

In fact, it throws light upon many other interesting problems connected with ocean life, and in no small measure aids us in the study of rocks, such as those of the Jurassic formation. This must be our excuse for quoting at such length.

This chapter contains seven illustrations out of many that could have been supplied. The seventh shows, in enormously enlarged forms, the spicules of 'various sponges.'

The sponges themselves vary from nine to fourteen inches in length.

The last point, and a very wonderful one it is, remains to be noticed. Long ago geologists were acquainted with beautiful objects which occupy the centres of certain flints found on the sea-shore and other places, and, not knowing their history, they called them *Ventriculites*. They are found in a variety of shapes, such as balls with stems, cornucopia forms, others are like wine glasses (see fig. 58), nd a great number have taken on the shapes of mushrooms and 'toadstools.'

Now, however, the finding of the living glass sponges enables us to classify these beautiful objects, for they are the euplectellæ of remote geological ages.

You may perhaps say, 'How about the

spicules in the sarcode?' Astonishing to say, if we take a thin piece of the flint next to the 'ventriculite,' and get a lapidary to polish it,

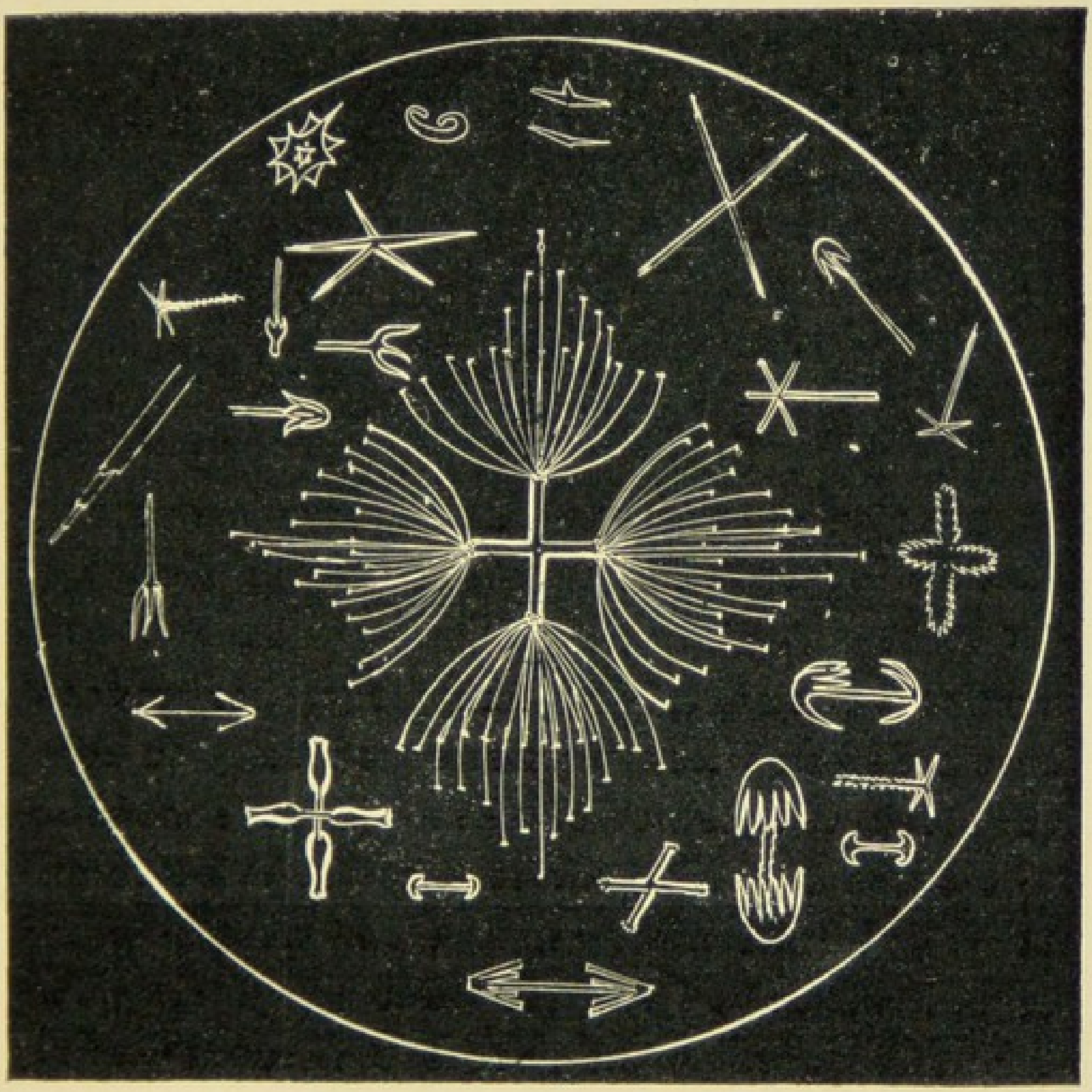

Fig. 13.—Sponge Spicules (see Fig. 58). Very greatly magnified.

the microscope will show us the spicules firmly embedded in the flinty envelope. We have picked up hundreds of these 'ventriculites,' or 'flint sponges' on the coast between Folkestone and Dover.

The beautiful choanites found on many flinty beaches, as at Folkestone, Eastbourne, Sandown, etc., are varieties of the same class of sponges which lived long ages ago.

Thus we get another peep into the history and the marvellous composition of our earth, and we begin to understand why it is the geologist is so fascinated with his work.

There are manifold fossil forms of sponges. They could even be extracted from a block of chalk with a penknife.

The Jurassic rocks of South Germany and Switzerland contain masses of fossil sponges, so that, judging from these and from the quantities of silicified sponges found in the chalk of France and of England, we are bound to infer that innumerable hosts of these attractive forms of life existed in the past on ocean floors that now form elevated tracts of country far removed from the sea.

The department of sponge life that we have had under consideration, whether as regards its living forms or fossilized representatives of ancient geological times, is worth great attention. If we want something to excite wonder, something to admire, something to put into our collections of curiosities, something with which to entertain others, here is an opportunity. Specimens can be obtained at very small cost. The fossil forms can be sought for on the sea beach or in the cliff, if we ascertain the proper localities. Study the choanites in the Brighton Museum, or those in the Museum at Canterbury, or the glass sponges at South Kensington. Possibly the sight of such things will prompt the reader to take up some hobby in this direction.

CHAPTER VI

ATLANTIC OOZE

If it were possible to descend to the floor of the Atlantic Ocean, at a point half-way between Ireland and America, where the waters are two and a half miles deep, we should meet with many objects which would attract our attention and excite our keenest interest. When our engineers, skilled in the practical application of electricity and magnetism, were making preparations for placing the first cable between our shores and the great western continent, they longed to know the exact nature of the bed of the ocean. Were there any creatures which could damage the covering of the cable, and thus expose the copper wires to the action of the sea water? If so, how could they live under such a terrific pressure? Were there any creatures sufficiently powerful to break the cable, or, was life so abundant that organisms would be attached to it in vast numbers? and if so, would their calcareous and other deposits form accretions detrimental to the stability and continuity of this all-important means of communication which they hoped would establish a common bond of commercial and friendly union between two great countries?

These and many similar questions were easier asked than answered. Still, such queries were the natural outcome of a curiosity aroused in every one interested in this colossal enterprise. Even one of the comic papers of those days fed our imagination by issuing an illustration representing Neptune driving away from the cable the mermaids or other fanciful denizens of the deep Atlantic waters. Reference to the poet gave us a crystallised summary of all that we knew of ocean floors, and what we should expect to see scattered upon them; but of 'the mysteries shrined in the cells of the sea,' the poet could not tell us anything new:—

'Shipwrecks and their spoils, the wealth of merchants, the artillery of war, the chains of captives, and the gems that gleamed upon the brow of beauty, crowns of monarchs, swords of heroes, anchors lost, that had never let go their hold in storms; helms sunk in ports, that steered adventurous barges round the wide world. Bones of dead men, that made a hidden Golgotha where they had fallen unseen, unsepulchred, but not unwept by lover, friend, relative far away, long waiting their return to home and country, and going down into their fathers' graves, with their grey hairs or youthful locks in sorrow, to meet no more till seas give up their dead.'

Thus the floor of the Atlantic remained an enigma, until the scientist overcame in part the difficulties attendant upon the enormous pressure, by constructing appliances which reached the depths referred to and brought up samples of the deposits known as 'ooze.' Subsequently the ocean bed was examined at several points, and as a result we know that the floor of the North Atlantic, for the greater part, is one vast bed of white calcareous matter, and that when this 'ooze' is examined under the microscope, it is found to consist mainly of the shells, or fragments of shells, of extremely minute creatures, known as globigerina. Myriads of these, and kindred tiny organisms, live on almost every square yard of the surface of this ocean. Vast numbers live a foot or two below the surface, and even the floor of the ocean is peopled with them.

The shells, though exceedingly small, are elegant, especially so when tenanted. They are also perforated, so that the jelly-like speck may protrude a multitude of feelers which interlace and form a meshwork arrangement for catching and bringing in food. Owing to

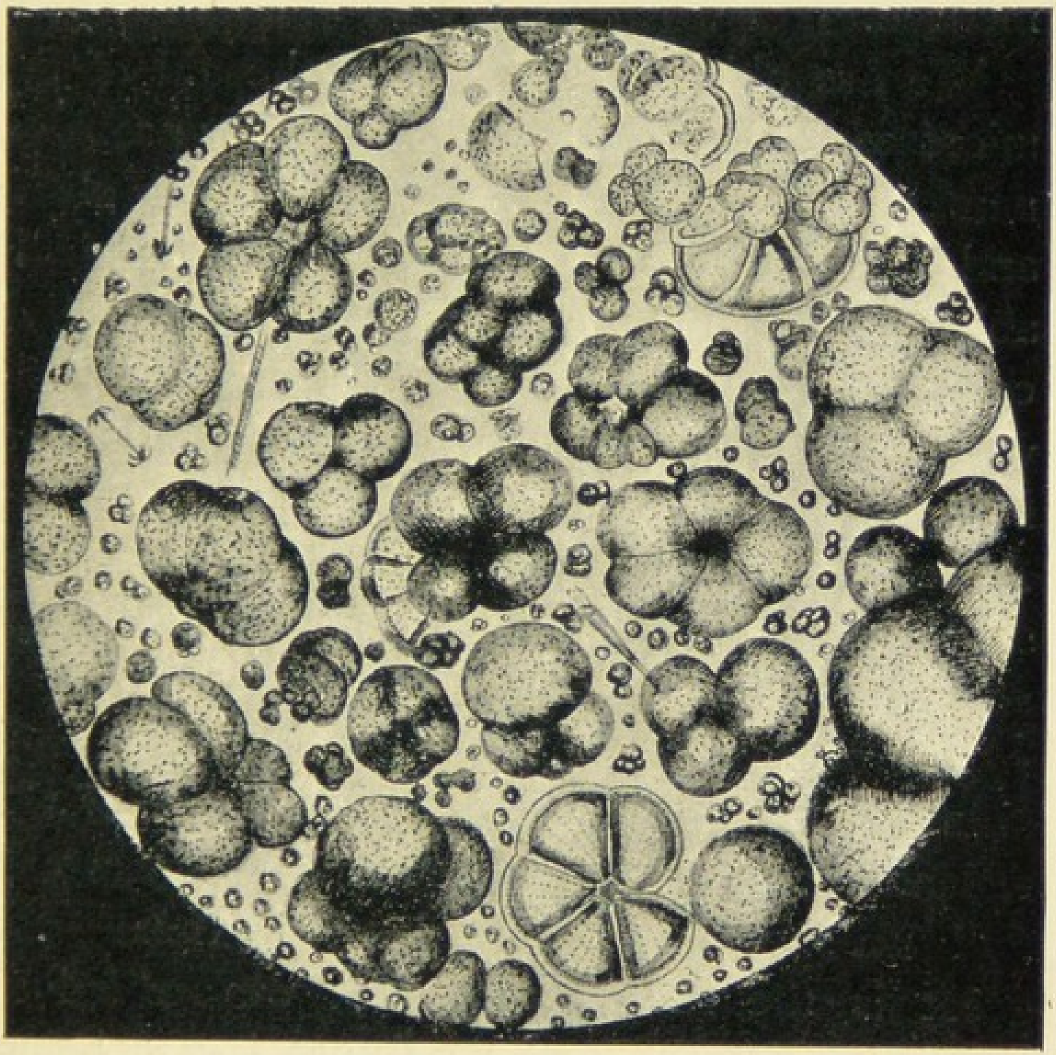

Fig. 14.—Globigerina bulloides. Very greatly magnified. 'Atlantic Ooze' from a depth of $2\frac{1}{2}$ miles.

these perforations, the shells of these and of other creatures are classed as Foraminifera.

The creatures die, and their shells descend to the floor below, where they form layer upon layer of chalky matter. We have as yet no means of knowing how deep this North Atlantic bed is now, nor of the time that has elapsed since this particular stratum was commenced.

We are able, however, with the aid of the microscope, to throw light on another problem, namely, the formation of the chalk of our cliffs; and although there may elapse some considerable time before we can say with positive certainty that the chalk of Europe and Asia was deposited on the floor of some vast ocean similar to the globigerina formation of the Atlantic, yet we seem to have one of the several keys required to unlock this geological secret.

The microscope tells us that the chalk consists of tiny shells, analogous to those of the Atlantic ooze. Experienced microscopists can find no special difference between them. So great is the resemblance, that we are led to think that the chalk of the future is now being deposited on certain ocean floors.

Any one with a microscope will find the comparison of the micro-fossils of the chalk with those of the globigerina an interesting study. Samples of the latter may be had from most slide-mounters. In the examination of the chalk, one point must be observed, which will prevent disappointment. It will be necessary to select a piece of chalk from the top layer of the cliff or bed, and to wash out the shells carefully with water and a camels'-hair brush. The shells are so small and so fragile, that it would be unreasonable to expect good specimens at the base of the cliff, where the pressure is so great, and where great changes have been taking place in the character of these lower or earlier deposits.

A cubic inch of globigerina ooze contains about one million shells! This was proved long ago by Ehrenberg.

The lecturer's illustrations on the blackboard, designed in chalk, and the chalk dust that falls from the duster, consist of fragments of tiny shells that contained tiny creatures untold ages ago.

If we take a bit of chalk, and with a razor we cut off a thin slice, so thin that it appears somewhat transparent, we shall be able to pass a light through it under the microscope, when the tiny animal remains will be distinctly visible. We can then photograph it through the microscope, and make a lantern slide which will, in large characters, exhibit every section of the shells *in situ*.

Although the globigerina creatures are so

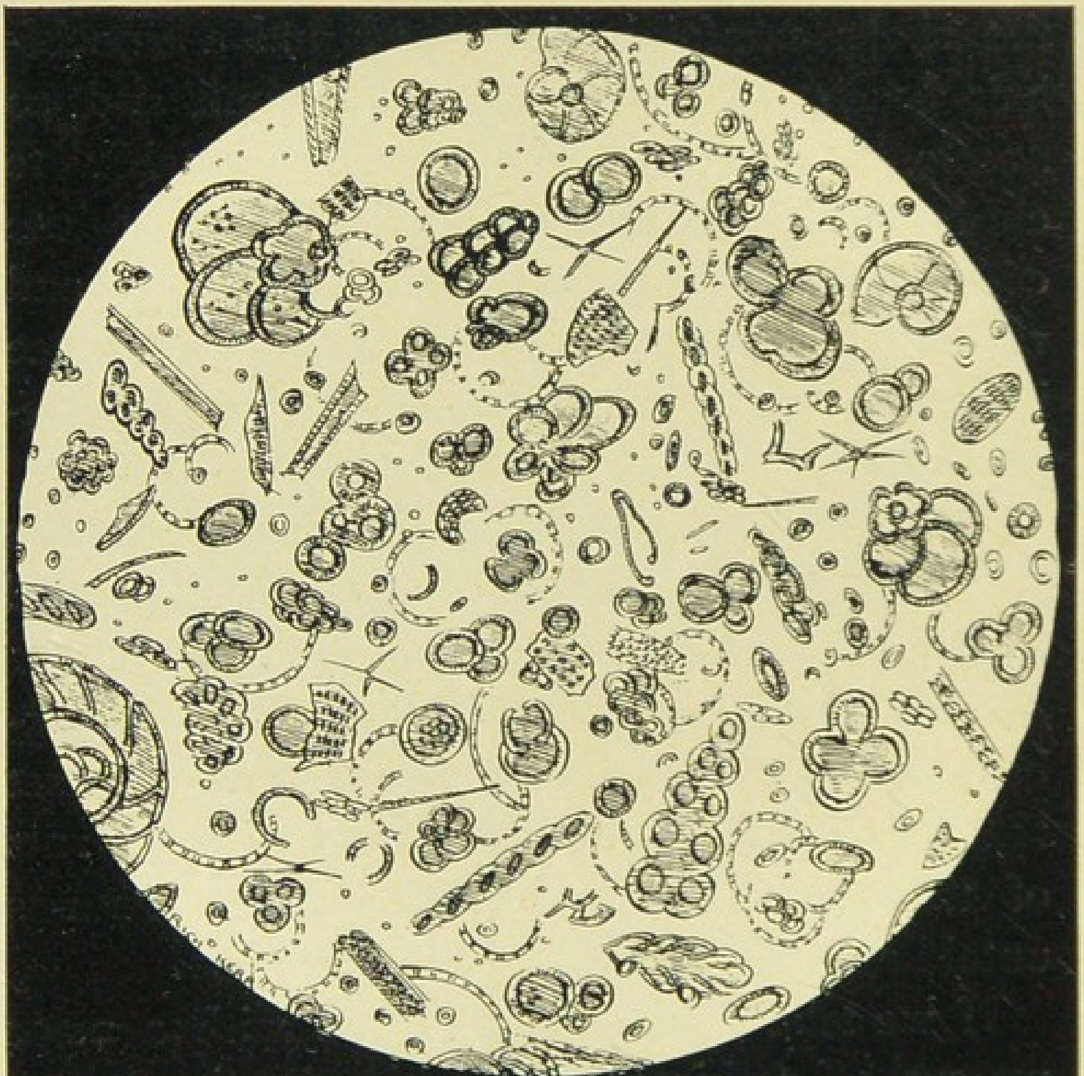

Fig. 15.—A thin Slice of Chalk. Very greatly magnified.

minute, they are a great factor in the building-up of this world, and, in reasoning from appearances, we are led to say that they have been so from very remote times. Should it be conclusively shown that the vast chalk beds of Europe and Asia have been laid down by the shells of ancient globigerina, we shall understand one of the grandest of geological problems. It is but fair to say there are some students of Nature who do not accept the theory that the chalk of the formations with which we are acquainted in various parts of the world was laid down by globigerina similar to those now found in the Atlantic. Able men like Jeffreys, Murray, and Renard, consider chalk to have been laid down in shallow waters, or on the borders of a continent, rather than in deep ocean areas.

Their opinions receive support, in a measure, from the fact that globigerina ooze contains a large percentage of silica, while chalk is nearly pure carbonate of lime. The chalk, however, contains many flint nodules. If at great depths, in ancient times, the silica of the chalk was dissolved, and taken up by glass sponges, the purity of the chalk would be accounted for. In support of this, there have been times when the solvent power of ocean waters was so great that arragonite organisms entirely disappeared from certain beds now forming limestone. The Challenger naturalists found that globigerina and pteropod ooze were completely dissolved below certain depths. Carbonic acid would, no doubt, play an important part in bringing about such changes. Dr. Wallich gives excellent reasons for supposing the flinty nodules in the chalk owe their origin to sponges (see the chapter on the Euplectella). The opinion that the deep-sea globigerina ooze is but chalk now being laid down, and that it in every way corresponds with the chalk of the cliffs, as at Dover and elsewhere, is gaining support.

There are some who even think there has been no break nor interruption in the continuity of the formation of chalk from the Cretaceous epoch down to the present time—that in fact we are living in the Cretaceous period. Geologists would find it no easy matter to find a line of demarcation between the globigerina ooze and the admittedly true chalk.

Whether we can reconcile the present with the past, or whether it be utterly impossible, the fact remains, that tiny creatures, the simplest of the simple in structure of sarcode, are now doing a stupendous work on certain ocean floors, and that creatures like them, if not quite identical, possessed of similar powers, secreted carbonate of lime in the remote past, and fulfilling the purposes for which they were created, passed away, leaving their shells to form extensive areas of chalk, hundreds of feet in thickness.

CHAPTER VII

FOSSIL POLYCYSTINA [1]

THE Chinaman will carve a solid piece of ivory in such a manner that when he has finished the performance, we behold to our astonishment a series of beautifully perforated balls, the lesser fitting inside the greater. Men of all nations admire the genius and the dexterity which produce such an artistically puzzling result. As 'a thing of beauty is a joy for ever,' so it is with the Chinese carving, but further than this it is not turned to any practical service. Now, we have no desire to minimise the ability or the patient skill of John Chinaman, but if we can refer to Nature and find an object very similar in shape, but so small that a million of them would fit comfortably into a lady's thimble, ought not our admiration to be drawn out in a much greater degree?

The skill and the wisdom here involved must

[1] Greek *polus*, many; *kustis*, a cyst, or box.

be far beyond man's power to comprehend. Besides, these minute objects, throughout their whole existence, are highly useful, and play a most important part in the great plan of creation.

We ought not to find it a very laborious task to ascertain definite information respecting these hidden beauties, for in the effort we shall be certain to grasp very easily one of the grand geological problems connected with the history of our earth. It is advisable then to cultivate a closer acquaintance with these marvels, to inquire somewhat into their history, and to find out the methods adopted by microscopists whereby they are able to unfold their incomparable beauty.

We will select, in the first instance, the fossil forms found in the rocks of the island of Barbados for our special attention, and afterwards we shall notice the living forms of the oceans. The numerical strength of these microscopic shells in this stratum baffles our imagination. A piece of rock which we could carry under one arm would contain more specimens than there are people on this earth.

For one shilling we can purchase a sample, prepared and mounted for the microscope, which will prove a lasting pleasure.

A space on the slide as small as that covered by a needle's eye is represented in the accompanying illustration. But this is only from a

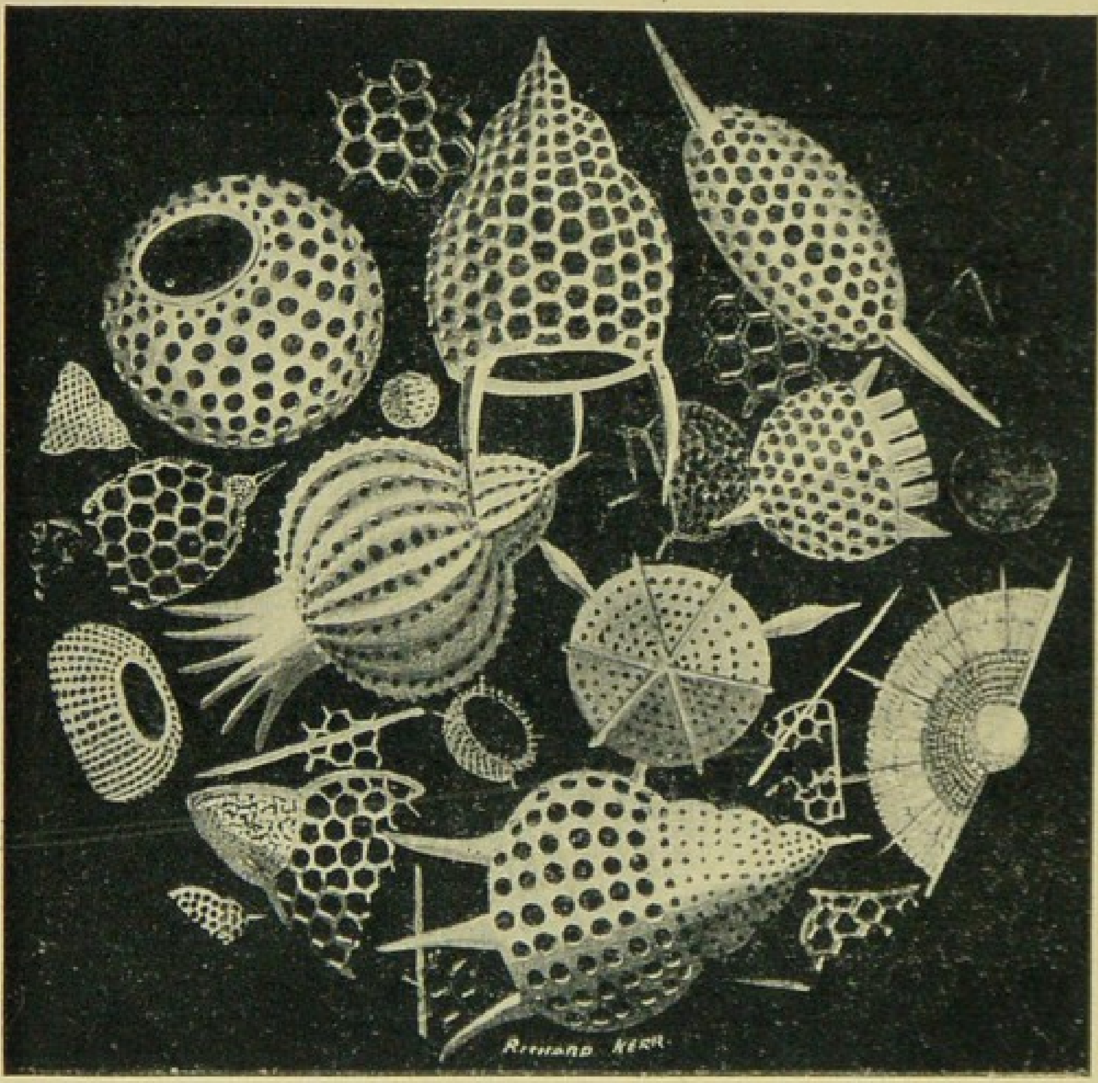

Fig. 16.—Polycystina. The composition of the Rocks of Barbados. Enlarged several hundred diameters.

drawing in white, reduced by photography, and falls far short of the real specimens. Drawings and words fail to convey an impression to the mind at all equal to that experienced after one peep at the real thing through the microscope.

Instead of purchasing a slide, it is more satisfactory to prepare the specimens direct from the 'raw material.' To do this it will be necessary to obtain a piece of the rock from some friend living in that part of the world, or from some geologist. As a rule, geologists have specimens in the natural and in the prepared conditions, and are always delighted to facilitate the study of their favourite science. Take a piece of the stone about the size of a pea and place it in a glass test-tube ; pour in some acid, either nitric or sulphuric, and some water; cover the opening, and shake the tube well. The acid will dissolve the carbonate of lime, *i.e.* the chalky matter, and the contents will appear milky. Pour out the liquid, taking care to keep back the sediment. Do this once or twice a day for three or four days, when the milky appearance will have passed away. The residuum is composed of the flinty shells you are seeking. Dry them. They will now look like a powder, so much so, that some people will tell you that you are showing them a sample of snuff. Place the so-called snuff on a glass slip, and bring the microscope to bear upon it.

You will then have a view before you which it will be very difficult to excel. To add to the effect, some slide-mounters heat the shells on a hot plate before mounting them.

This gives a pearly white appearance, and when viewed with a light thrown on them, the effect is most pleasing. To view them in this manner it is best to place a black disc of paper on the underneath side of the glass slip, thus shutting out any light below.

Some mounters prefer to arrange them without any disc underneath, and to treat them as transparent objects by throwing a light through them from below. Others mount them in fluid glycerine, so that they are free to move about. Viewed transparently, as in this last method, when the polycystina roll down they appear to take the opposite direction, and the effect is charming. They roll over and over, and display every portion of their symmetrical outlines, many of them showing the inner concentric perforated balls which resemble the ivory ones to which we have referred. The pattern is not, however, limited to the ball series, for we find cups, and helmets, and bowls, and mitres, in endless succession. Whether it be viewed under the microscope, or in a greatly enlarged form, as on the lantern screen, a slide of polycystina always creates profound admiration.

The fossilized varieties, as we have seen, are doubly hidden, in that they enter into the composition of certain rocks, and when separated are so small that a good microscope is required to render them individually visible. Although labouring under the great disadvantage of being lifeless—for, long ages ago, they were deprived of their exquisitely beautiful tenants, and now consist only of the flinty, forsaken homes—yet they are so wonderful and so attractive that view them as often as we may, we can never tire of them. We are always ready to see them again, and we put them in the foreground at all meetings where the public is invited to see wonders revealed by the microscope. We must be careful not to confuse the polycystina with the homes of other creatures whose shells also form vast deposits in certain parts ot ocean floors, but which consist of chalky or calcareous matter. These have been dealt with in another chapter.

The rock structure of the Tertiary period in certain localities consist of marl, tripoli, and sandstones, composed mainly of the flinty skeletons and shells of the polycystina family of Radiolaria.

In another chapter two examples have been mentioned by way of illustration, namely the rocks of the Barbados and those of the Nicobar Islands. The former attain to a height of 1,100 feet, and the latter to 2,000 feet in thickness. The microscopic rock-making creatures of the world, at whatever period, have never excelled in beauty or in complexity of structure the fossil polycystina of the Barbadian rocks. When exhibited under the microscope with proper illumination, they constantly excite wonder and admiration.

These fossil shells that are so beautiful, notwithstanding that they have been for ages pressed together and consolidated into rocky strata hundreds of feet in thickness and miles in extent, must have had at one time living tenants, possessing power to take in food and to appropriate flinty matter suspended in the waters of an ocean that has many times over been evaporated! What a number of tremendous problems at once confront us! If some millions of these shells could be contained in a cubic inch of space, what about the unnumbered hosts of shells that are embedded in the Barbadian rocks alone? What duration of time must have existed between the deposition of the first layer of shells on that ocean floor

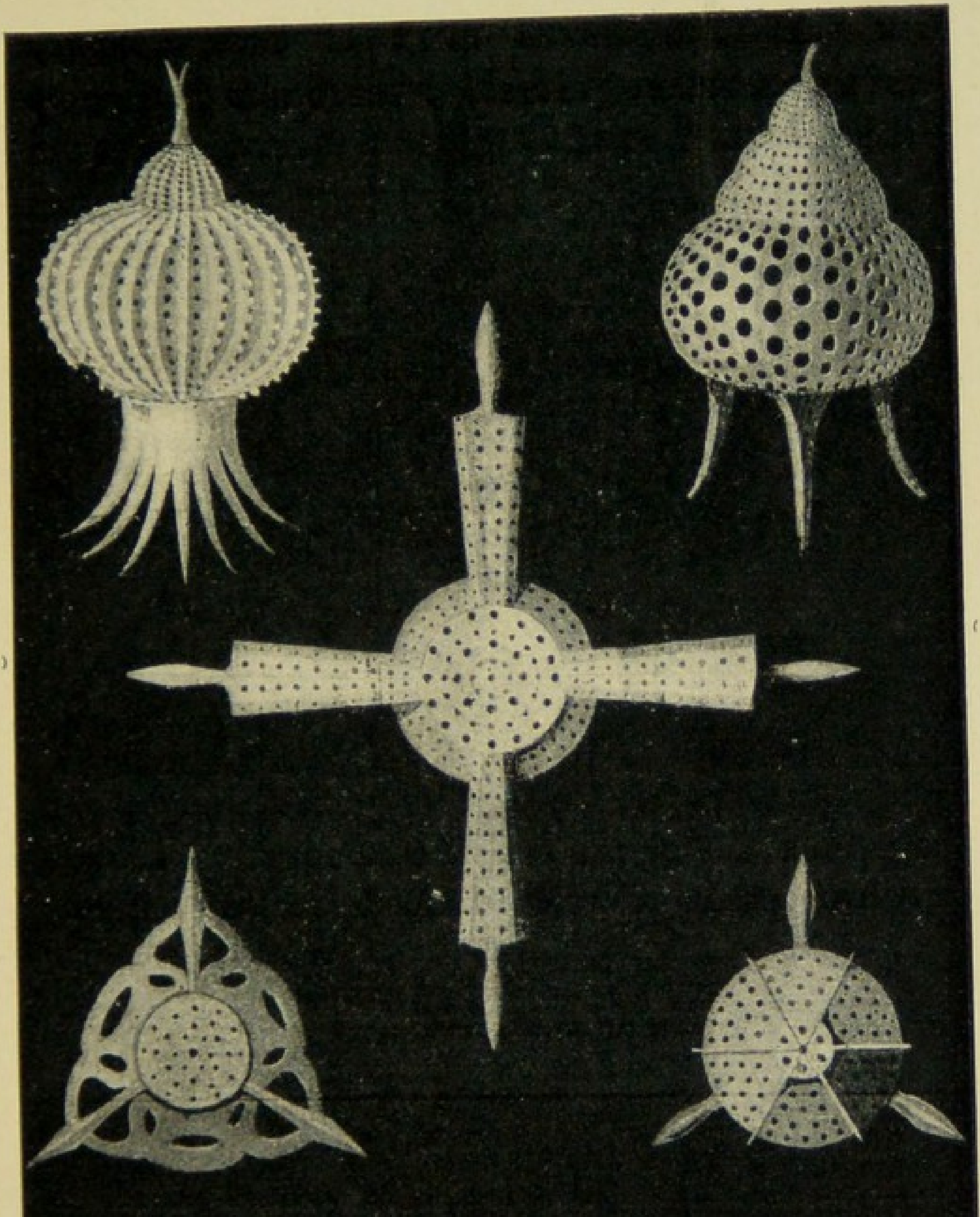

Fig. 17.—Polycystina, Island of Barbados. Enlarged many hundred diameters.

and the last stratum on the top! What must have elapsed in order to allow for the solidification of all this aggregation of shells into hard rock! Why is so much surpassing beauty hidden that can never be seen by mortal man? Why do so few people care to seek pleasure in such studies?

CHAPTER VIII

RADIOLARIA

PASSING from the fossil forms of microscopic shells of flinty structure, known as polycystina, we come to their living representatives; for we are often asked, when describing fossils, whether there are any creatures now having shells at all like them. If the fossil shells embedded in the Barbadian and other rocks be so beautiful, we shall naturally expect to see much greater attractiveness in those forms that are endowed with life.

Like the polycystina of the remote past ages, those that live at the present time are all marine and microscopic. They are found on the surfaces of oceans, protruding their tiny feelers through multitudes of openings in their flinty shells, and drawing in nutriment for their subsistence. They are marvellously beautiful, and highly sensitive.

To examine them satisfactorily, we should have to go to certain parts of the Atlantic or

Pacific, and in calm weather enter a boat and skim a few square feet of the surface, return at once to the ship, and place the water and its contents under the microscope.

We are indebted to the naturalists of the 'Challenger Expedition,' and to Professors Haeckel and Alexander Agassiz, of America, for information about, and drawings of, these wonders of the oceans.

So vast were the collections of Radiolaria[1] brought home by Sir Wyville Thomson and his scientific staff, that their classification, description and measuring, for the purpose of accurate illustration, occupied Professor Haeckel ten years. This industrious and skilful savant believes that a lifetime would not be sufficiently long in which to make a complete classification of all the forms of Radiolarians alone. His report on this branch of marine life fills three large volumes, comprising 1803 pages of printed matter and 140 plates of illustrations.

We have copied from the Challenger Report a few of the plates, to show the marvellous structure of these hidden beauties of ocean waters. Professor Haeckel and his assistant

[1] Lat. *radiolus*, a little ray.

made over 8,000 micrometric measurements of these objects. Bearing in mind that they

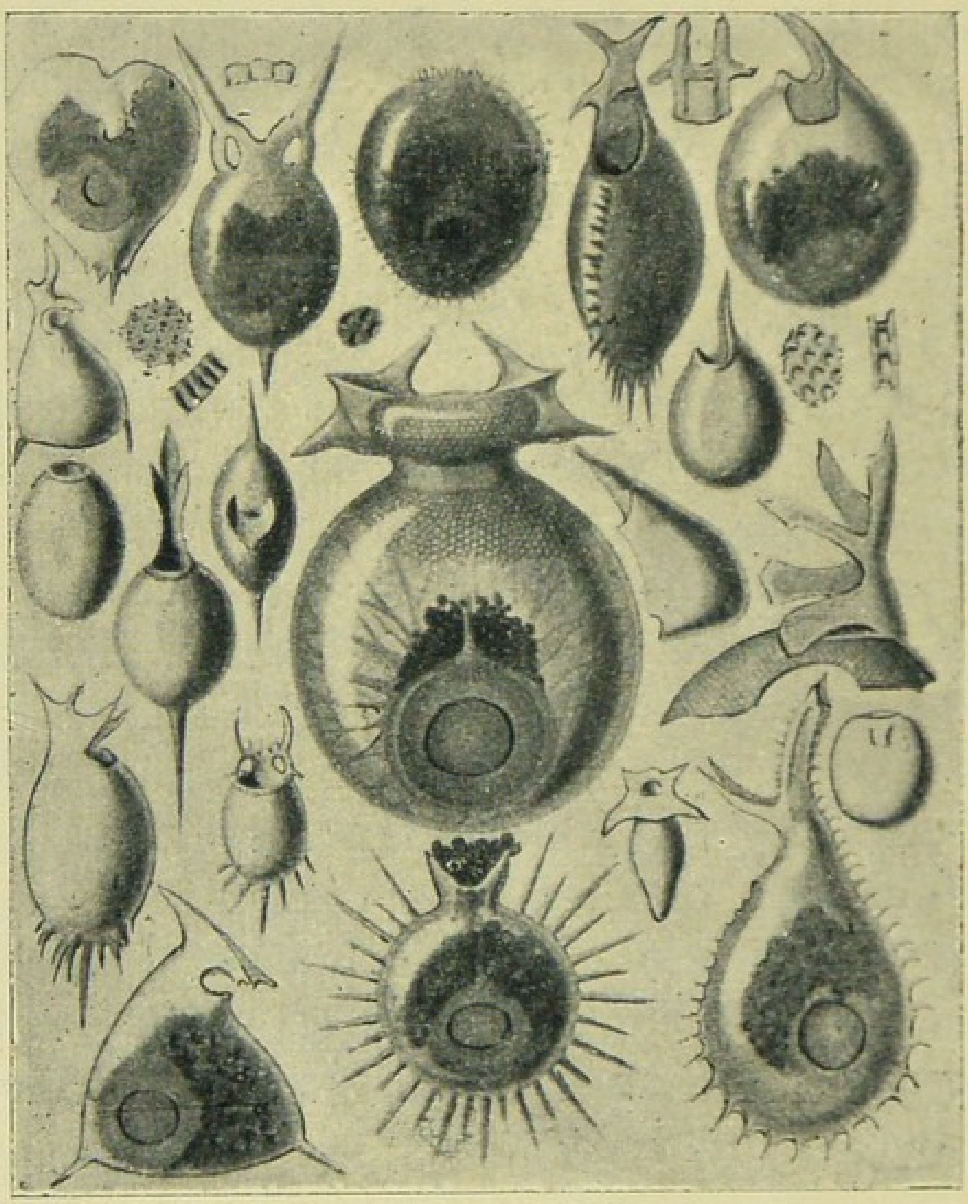

Fig. 18.—Radiolaria.
(Challenger Series.)

are all microscopic organisms, we shall realise that we are considering some of the most astonishing things in creation.

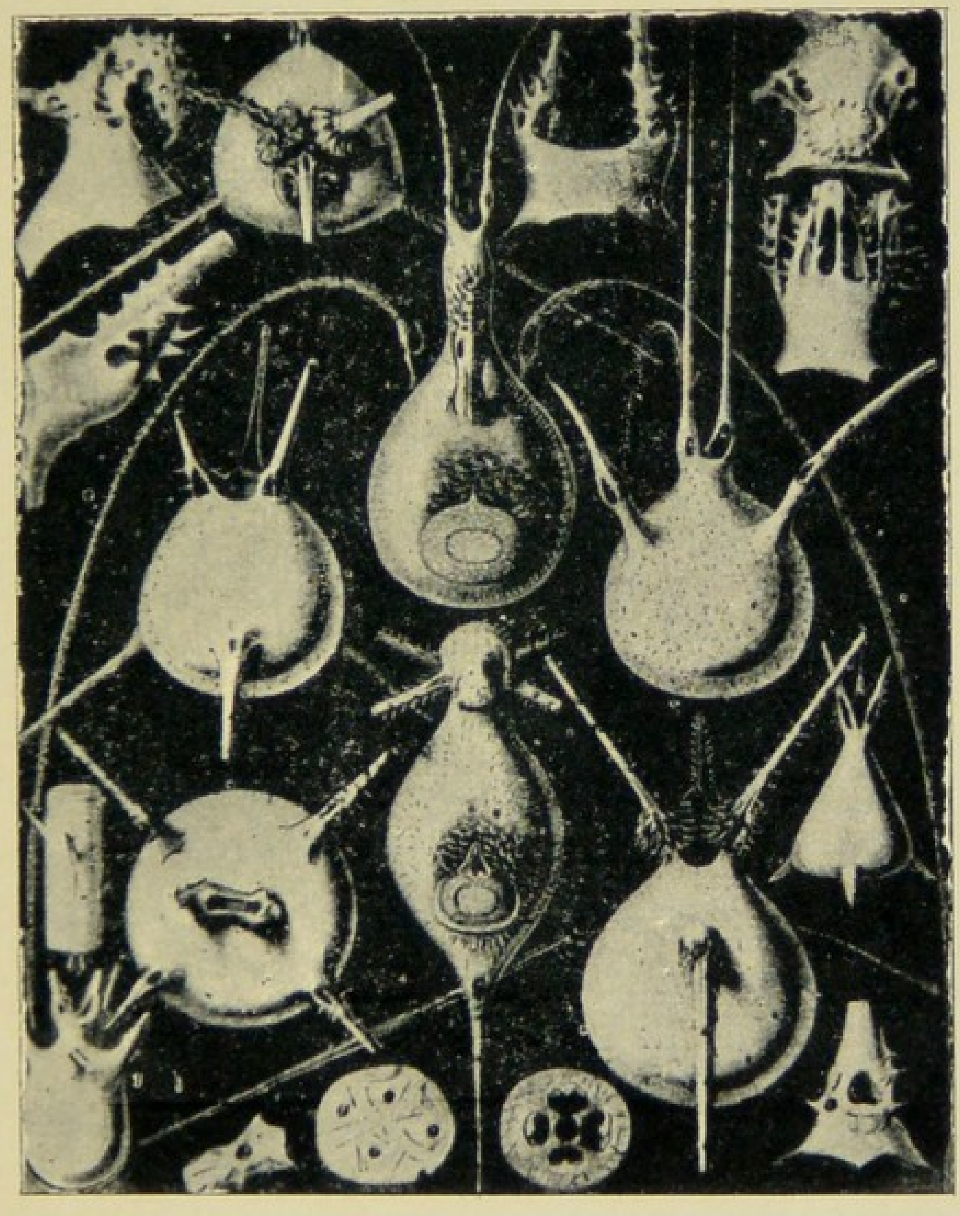

Fig. 19.—Radiolaria (Tuscarora).

The largest of them is one-tenth of an inch, the great majority are about one-fiftieth of an inch, while many are as small as the two-hundredth part of an inch. Of these latter, 8,000,000 would be required to occupy a cubic inch of space.

It is the generally accepted theory, that as the creatures die their shells gradually fall to ocean floors, and in time form deposits many feet in thickness. These floors in the course of ages are gradually raised up, and form solid land. A portion of such an ocean floor forms the island of Barbados. The Nicobar Islands are a similar formation in this respect. In the former, the silicious[1] sandstone with these embedded wonders attains to a thickness of 1,100 feet, and is miles in extent. Professor Haeckel holds that these beautiful forms of life are found in all the zones, extending from the surface to a depth of five miles. This view is not accepted by Dr. Agassiz. He contends that there is a fauna—or life group of animals—characteristic of the surface, and another equally peculiar to the bottom, but that there is no intermediate fauna. It is quite possible that, during the daytime the creatures of the surface

[1] Lat. *silex*, flint.

might descend to a considerable depth in order to escape the light, heat, and the disturbing influences of surface winds; but below two hundred fathoms there is a barren region, until at some sixty or seventy fathoms from the bottom, the deep-sea denizens in all their queer shapes begin to appear.

Instead of troubling the reader with the lengthy, almost unpronounceable names of the individual organisms in the accompanying illustrations, we designate them by the name common to the whole family, viz. Radiolarians. This name arises from the fact that all the tiny creatures send out innumerable feelers in all directions, as we have already indicated. Professor Haeckel accounts for 739 genera, and 4,318 species. What a picture of varied, complex, and beautiful patterns! What hints and ideas the exquisite shapes of these microscopic homes ought to supply to manufacturers and designers! What intelligent human being can look upon these wonders of 'infinite skill,' and yet believe that there is no Designer in Nature!

The ornamental vase-maker will find suggestions in the graceful curves of figs. 18 and 19; the basket-maker can take a hint from fig. 20 when designing something especially beautiful.

Fig. 21 looks like a collection of monograms, the central figure has an astronomical appearance, and solves in a moment the question of

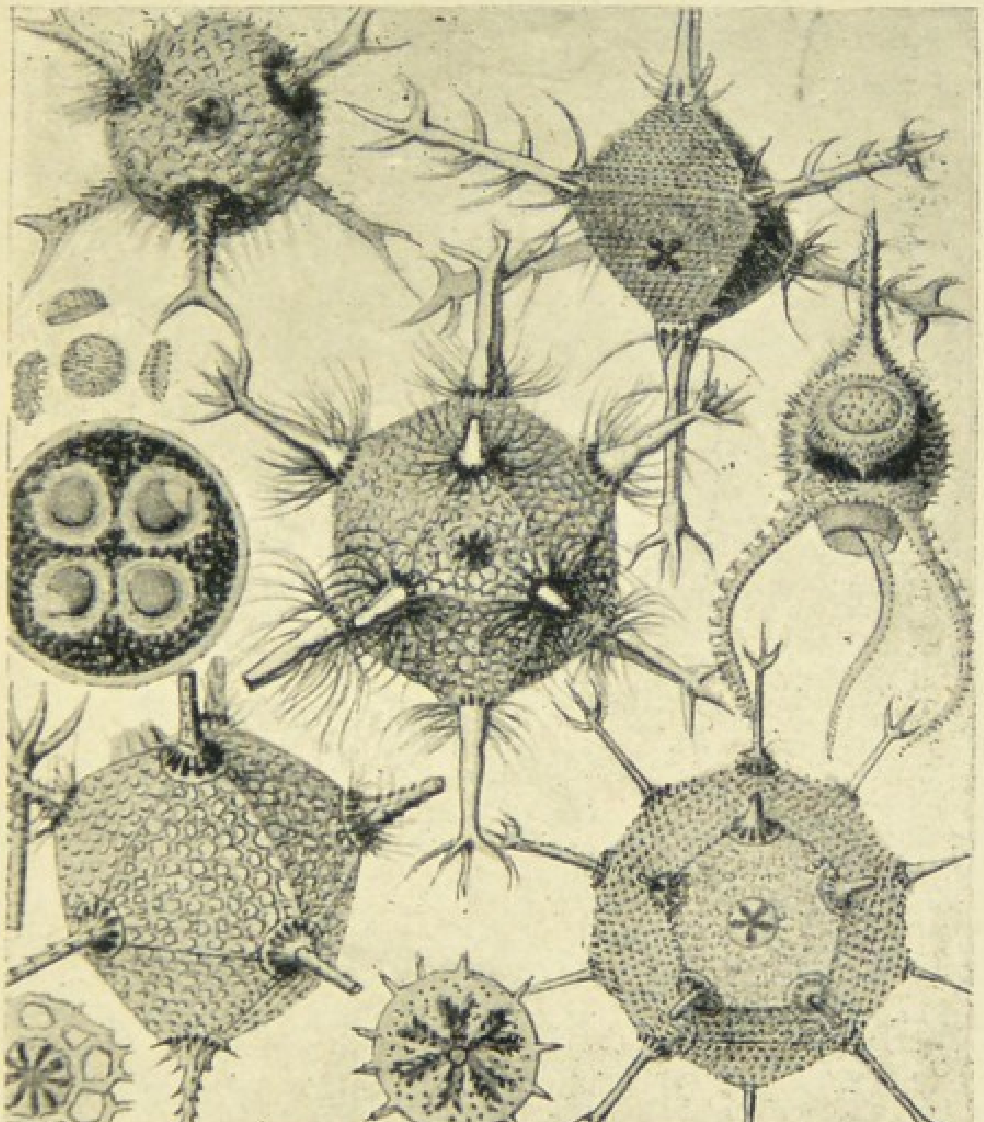

Fig. 20.—Radiolaria.
(Challenger Series.)

how to place three circles so that they shall have the same centre; the lower design in the left corner, is a well-shapen crown. Fig. 22 calls to mind a collection of gyroscopes. We

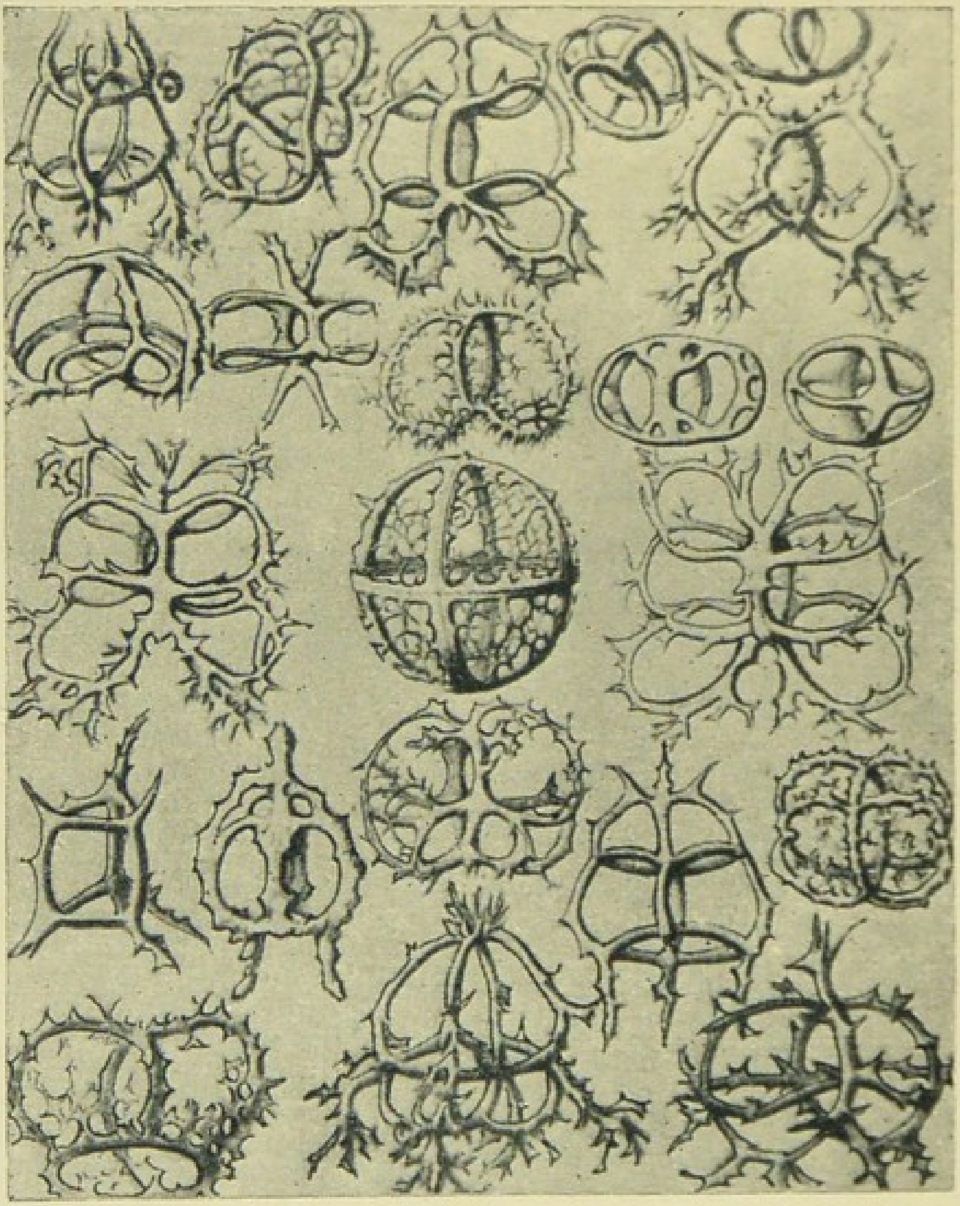

Fig. 21.—Radiolaria.
(Challenger Series.)

have no means of knowing whether these lowly creatures gyrate, but they certainly give the impression that they do. Light-houses (fig. 23), pendant lamps, thistles (fig. 28), brushes, screws (fig. 29), and spheres, are depicted with adorning surroundings, and yet they are practically unrecognisable without a microscope. Had we before us the whole of Haeckel's collection, we should find all the way through ever-varying designs and beauty not thought of by the most inventive genius. But the professor tells us that a whole lifetime is not sufficient for the examination of all the Radiolarian forms of our oceans! When all the land animals, the plants, the rocks and minerals of the globe have been classified and described, the oceans will continue to be a field yielding discoveries of the most interesting character. It is hardly necessary to state that such wonderful abodes of minute forms of life are among the hidden beauties of Nature; and if these are so strikingly beautiful in an untenanted condition, what must they look like when the living creatures display in addition their own coloured sarcode?

These are marvellous creatures. They are exclusively marine, and belong to the great division known as Rhizopods. They comprise many wonderfully beautiful forms, living and swimming in vast multitudes in the surface waters of the ocean. They are microscopic and the most complex in their structure of any

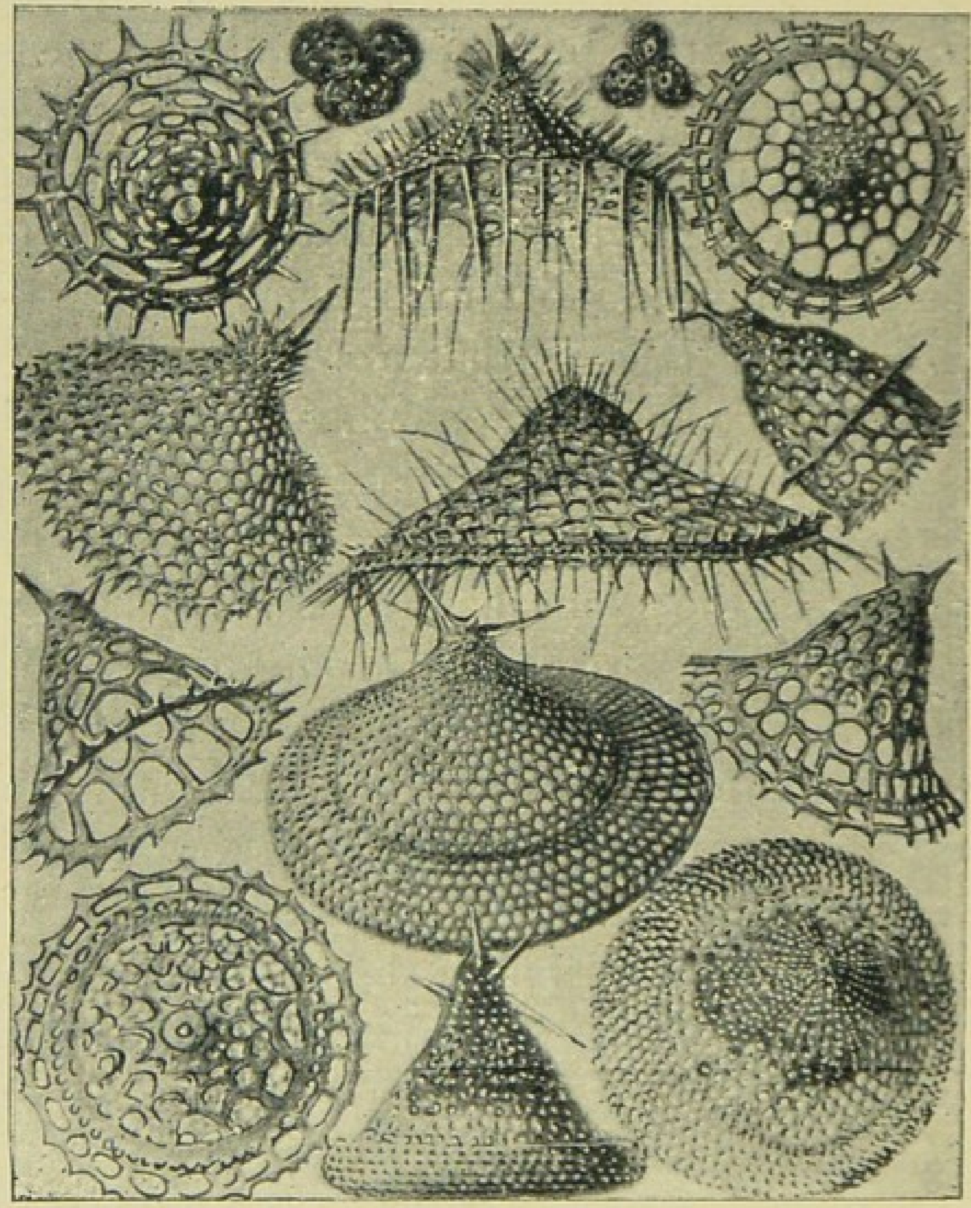

Fig. 22.—Radiolaria.
(Challenger Series.)

of the minute forms of marine life. They are furnished with a flinty skeleton, which, in variety of form, symmetry, and intricacy of construction, is a marvel of beauty. Some-

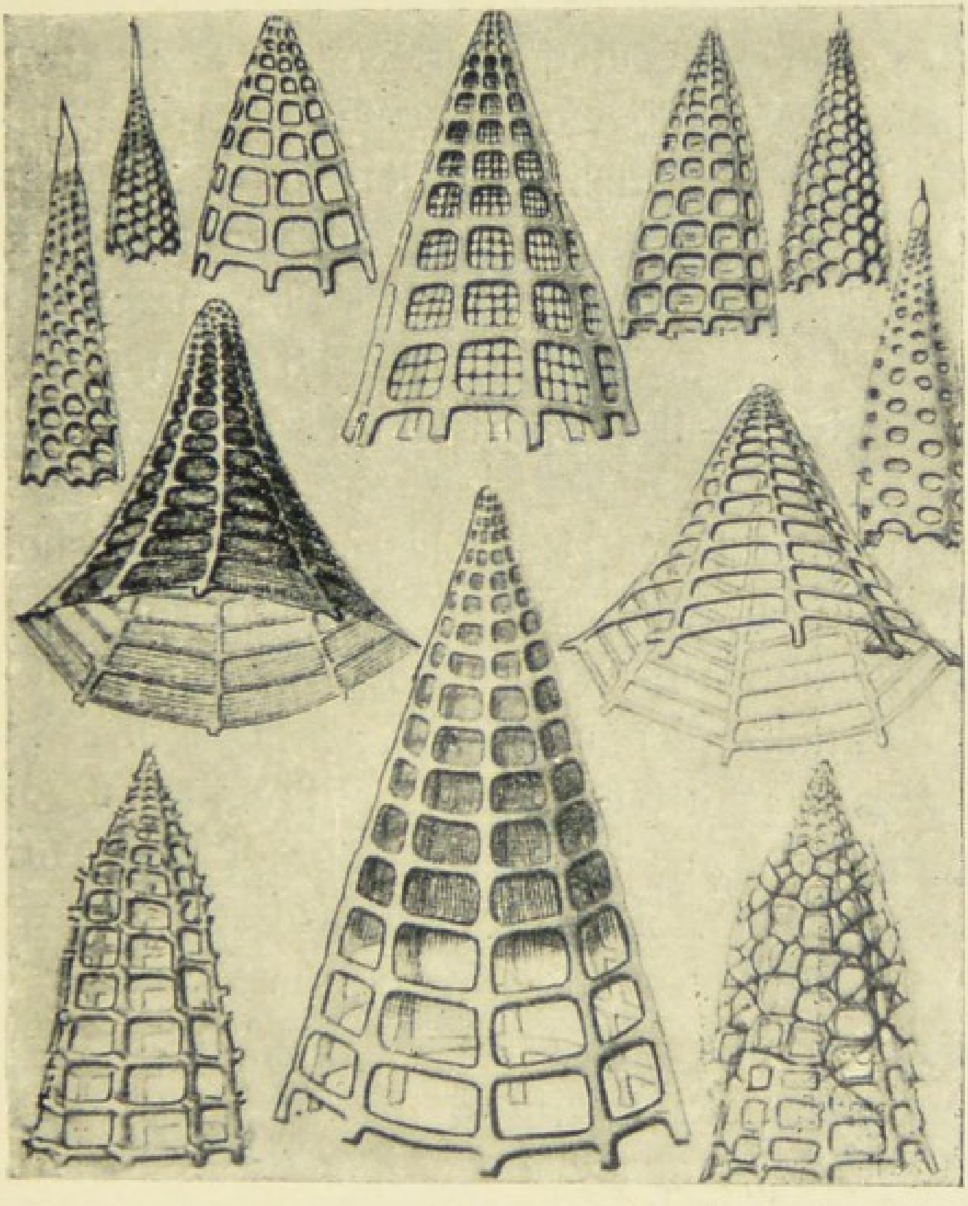

Fig. 23.—Radiolaria.
(Challenger Series.)

times the skeleton or supporting structure consists of a simple trellised ball, sometimes of a series of several such balls enclosed concentrically, and connected together by radial bars. Many are furnished with delicate spikes radiating from the surface of the perforated balls. Professor Haeckel says that 'no other group of organisms develop in the construction of their skeleton such a variety of fundamental forms, with such geometrical regularity and such elegant architecture.' The material of the skeleton or shell is derived from the exceedingly small proportion of silex contained in ocean water.

After death, the Radiolarian shells or skeletons sink to the bottom of the ocean, where they accumulate as an abundant component of the 'mud,' disrespectfully so called. The greatest recently-formed layer of modern Radiolarian shells occurs on the floor of the central Pacific Ocean. But we have, as yet, no certain means of ascertaining its depth. Neither do we know anything as to the date of the commencement of its deposition.

Professor Haeckel looks upon the Radiolarian as a creature organized more highly than the Foraminifera, which take up and secrete chalky matter. He says that each creature consists of a central capsule of firm membrane enclosing masses of minute cells. The exterior of this capsule contains numerous yellow cells, which enclose starch grains, and from it emanate in

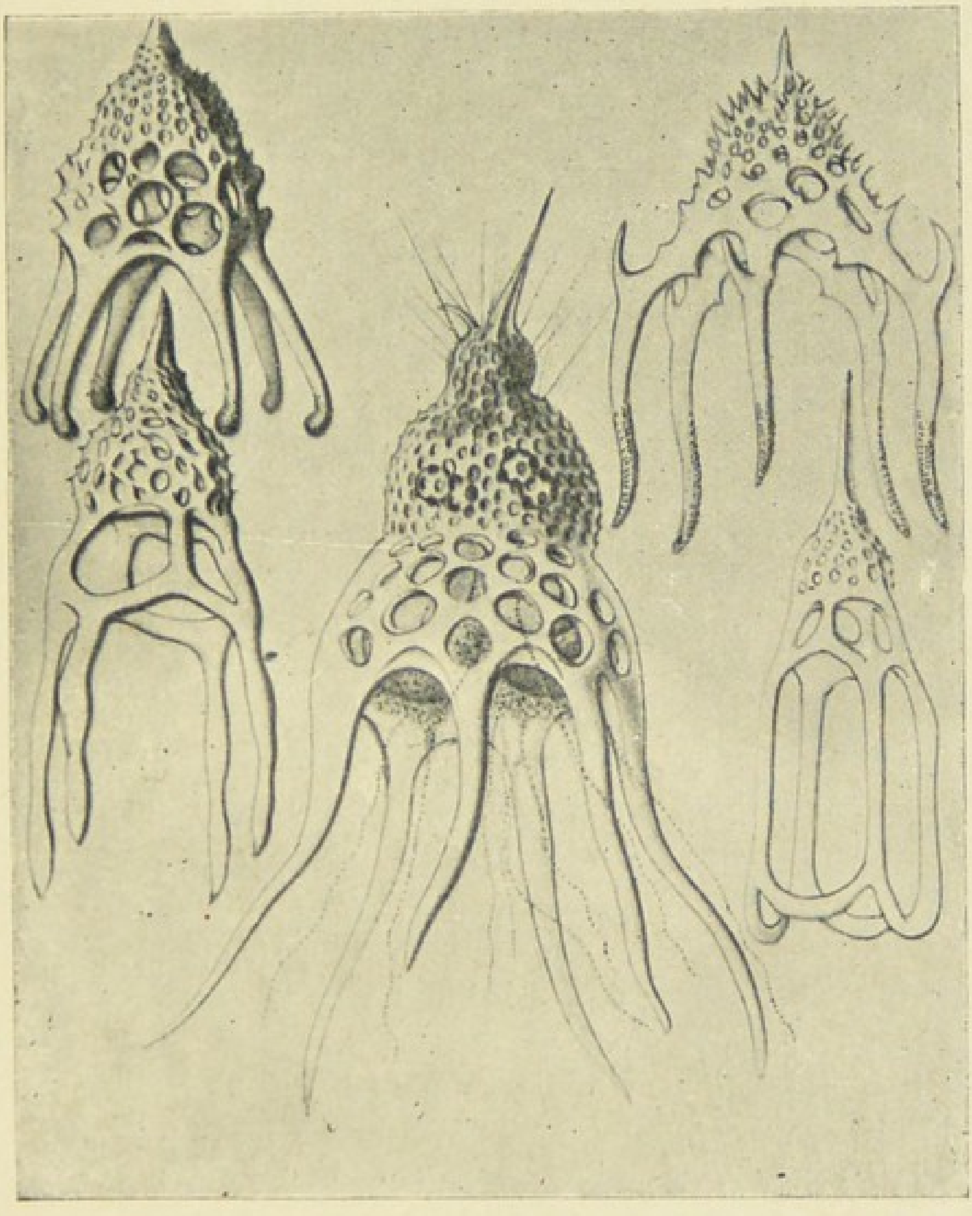

Fig. 24.—Radiolaria.
(Challenger Series.)

all directions countless feelers or pseudopodal rays. By means of these rays the creature draws in its food.

Closely allied to these Radiolarians, if at all separable from them, are most extraordinary

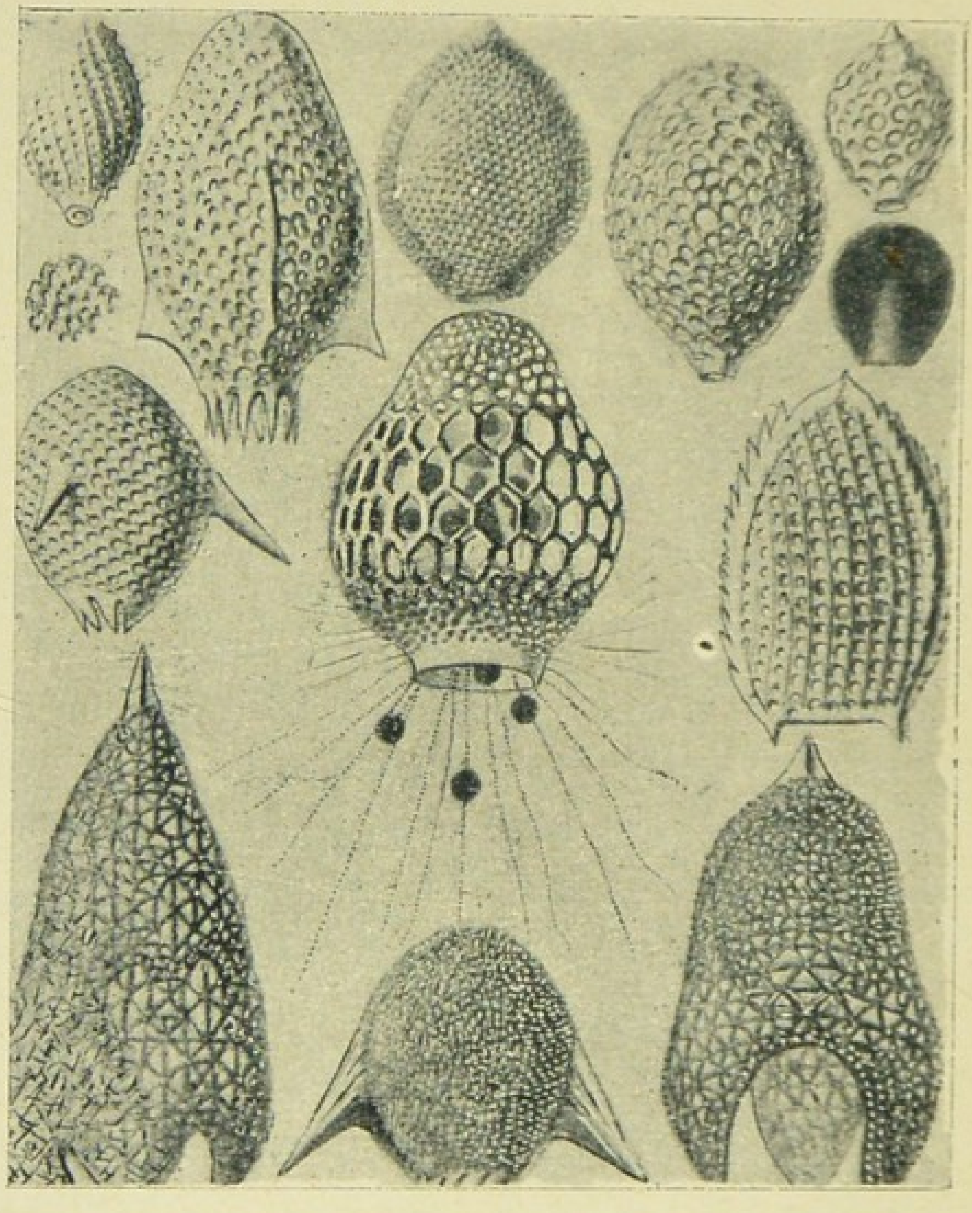

Fig. 25.—Radiolaria.
(Challenger Series.)

creatures called Challengeria and Tuscarora after the well-known ships formerly employed for scientific purposes of a peaceful character.

They form beautiful groups of minute life. They are smaller than the average Radiolarian.

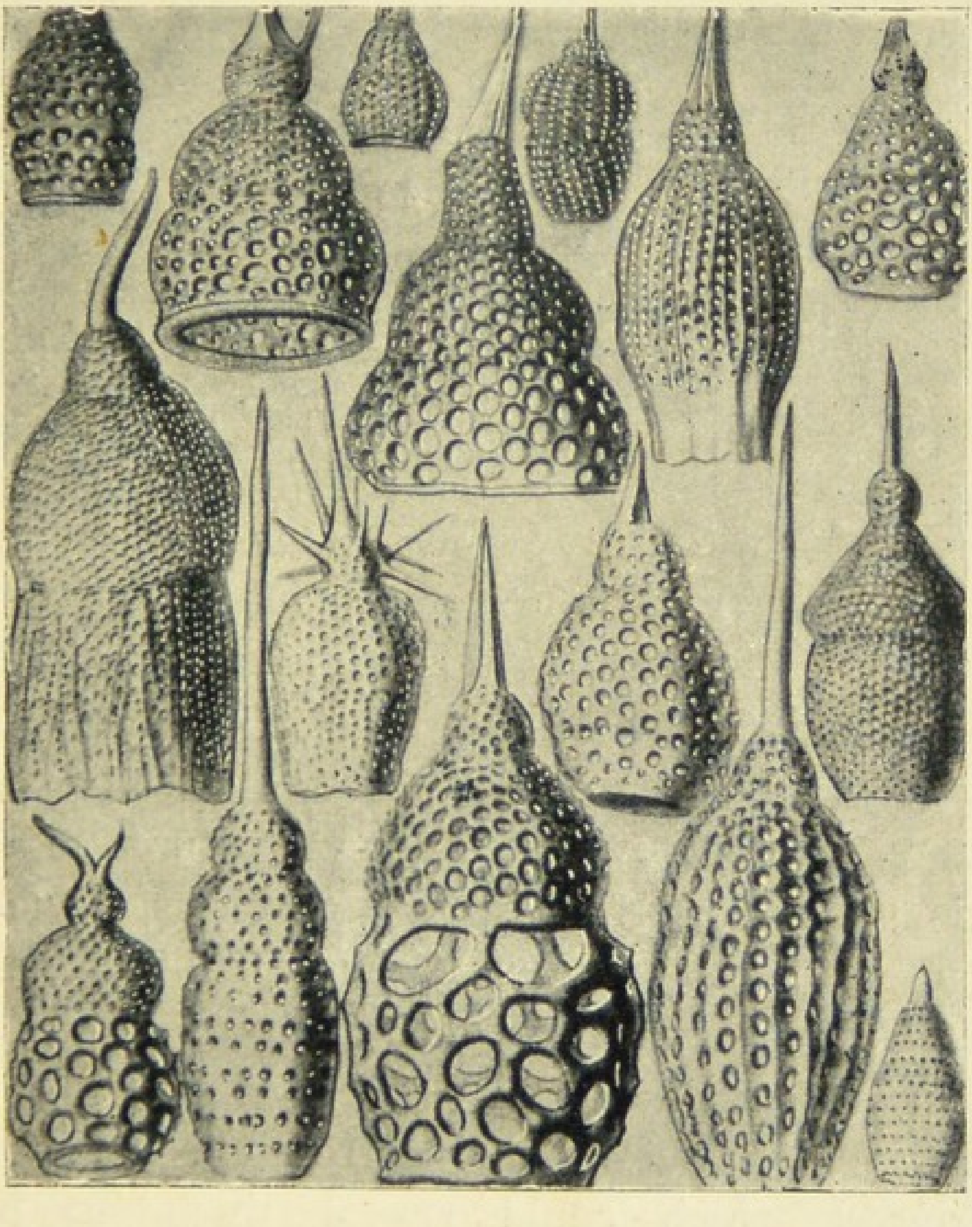

Fig. 26.—Radiolaria.
(Challenger Series.)

'They consist of a single chamber of silica, varying in form. Sometimes they are triangular, sometimes lenticular (like a lens, or lentil seed), and frequently globular or flask-shaped, with a single opening, usually guarded by a beautifully formed and frequently highly-ornamented lip.' (See figs. 18 and 19.)

They are extremely microscopic, varying from the hundredth to the two-hundredth of an inch across. Yet the curves, the proportions, and the general beauty of these shells are very striking. The modeller in china clay or terra-cotta, might easily copy inferior patterns to these. All the beauty of these designs is enclosed 'within the dimensions of a point,' and that a very minute point indeed!

One cannot look at these Radiolarians without noticing the striking resemblance which many of their forms bear to objects artistically wrought by man. We find architectural decorations, vases in a multiplicity of forms, devices suggestive of jewel-work, cups, balls, lamps, etc., etc. Man cannot have copied his ideas from these objects, because he made such things long before any microscope was constructed which could reveal them to his vision. On the other hand, the microscopic creatures could not have imitated man. In fact, their beautiful shells and skeletons grew long ages before man's appearance on this earth. Whence then comes this parallelism of design?

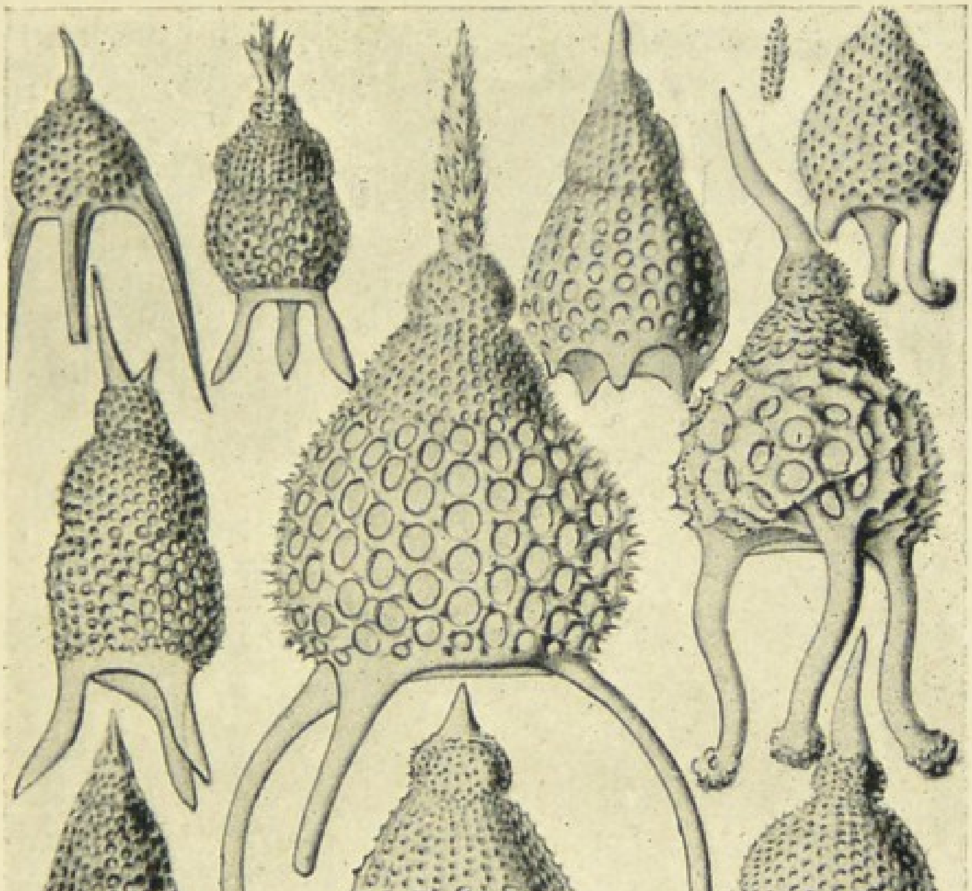

Fig. 27.—Radiolaria.
(Challenger Series.)

The question is worth a moment's consideration. Before answering the question, or suggesting what may be an answer, let us see if the student of the microscope has found in any

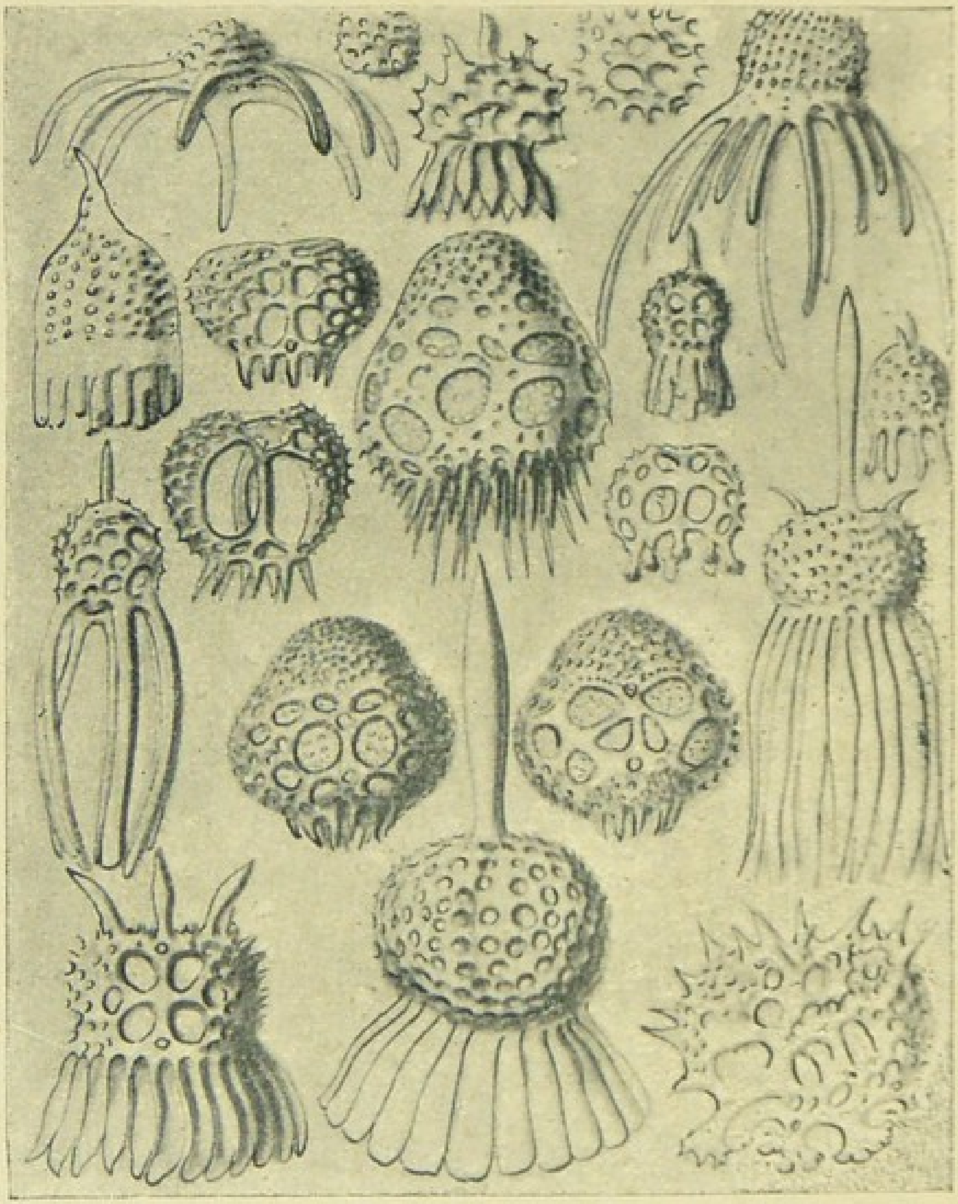

Fig. 28.—Radiolaria.
(Challenger Series.)

other department of microscopic life than the Radiolarians, any similar parallelism of design. He will tell us that he is constantly meeting with objects that are exceedingly

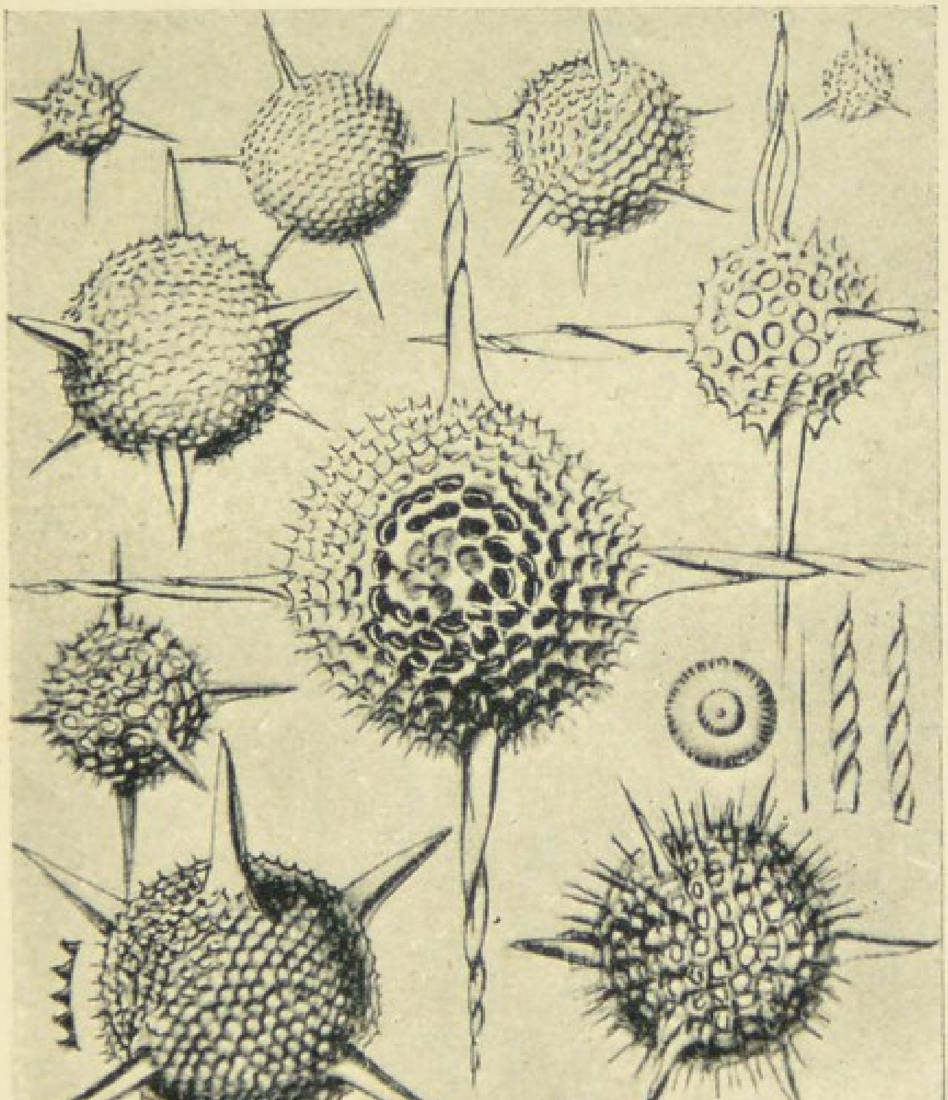

Fig. 29.—Radiolaria.
(Challenger Series.)

minute, which bear the closest resemblance to objects used in the arts, in science, in trade, and in domestic life—that this is a special feature in microscopy which attracts the atten-

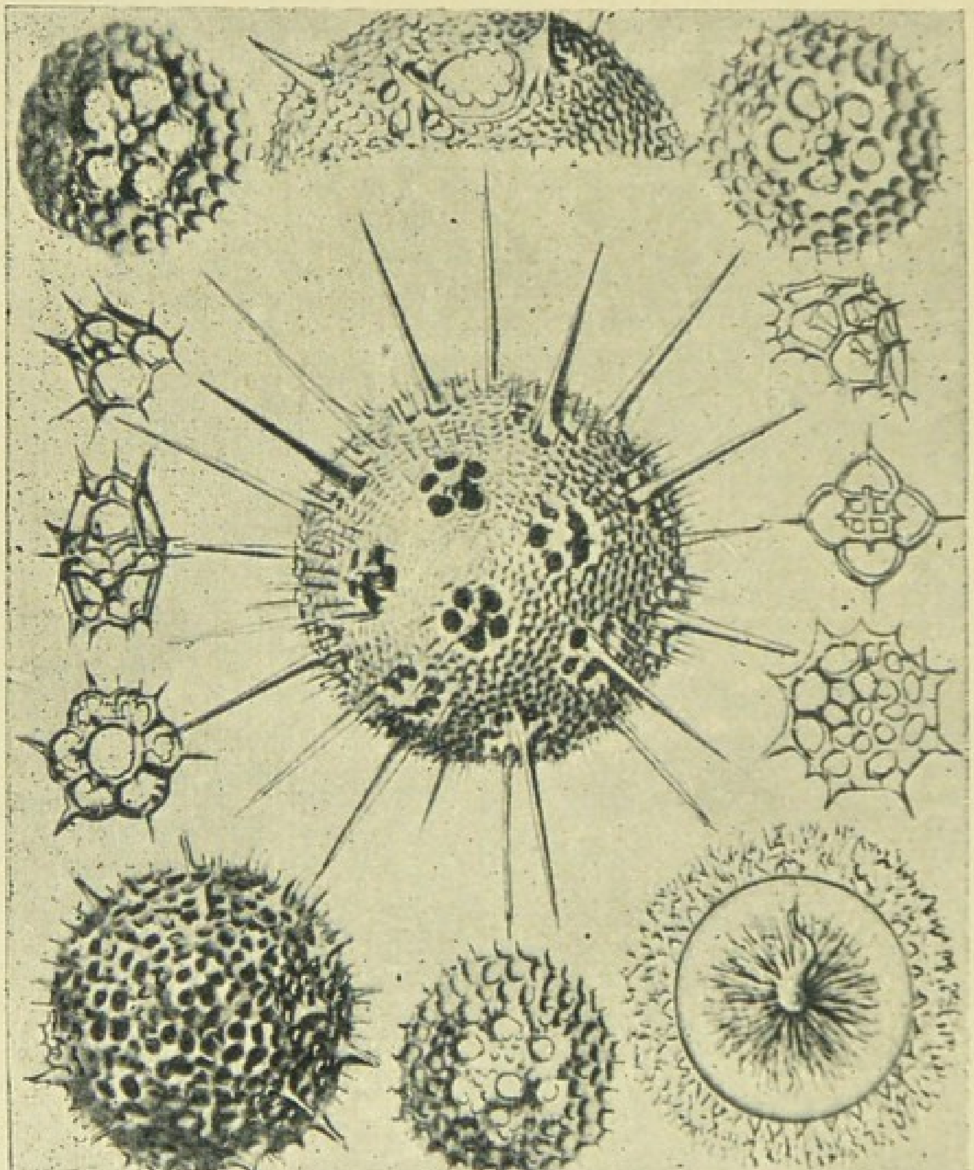

Fig. 30.—Radiolaria.
(Challenger Series.)

tion of every student. The answer then that must suggest itself is, that the human mind, in this respect, is a faint reflection of the Divine mind. What other answer can we give? We

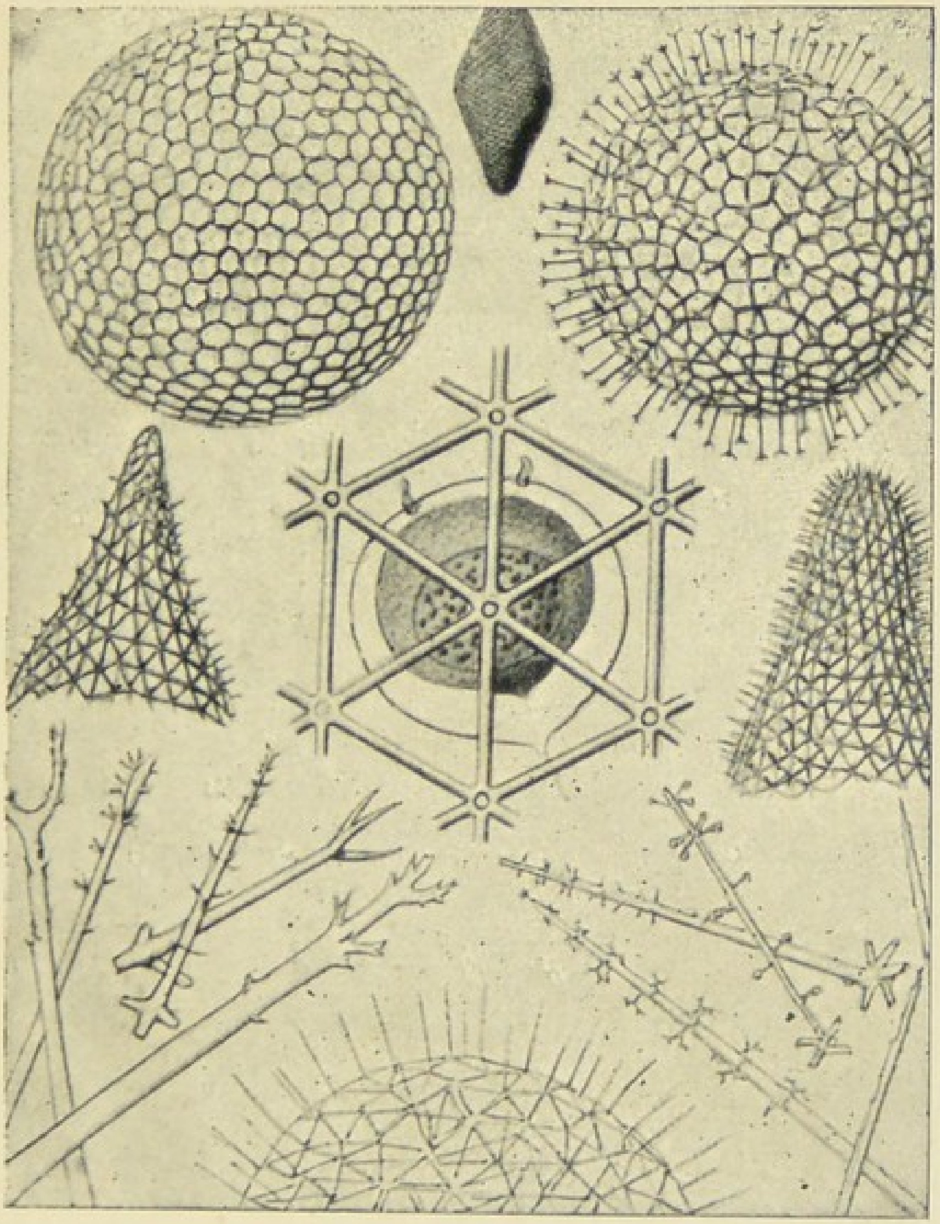

Fig. 31.—Radiolaria.
(Challenger Series.)

may enter into deep theories and learned reasons, which may only bewilder us. If the mind of man produces designs previously existing in microscopic nature, of which he had

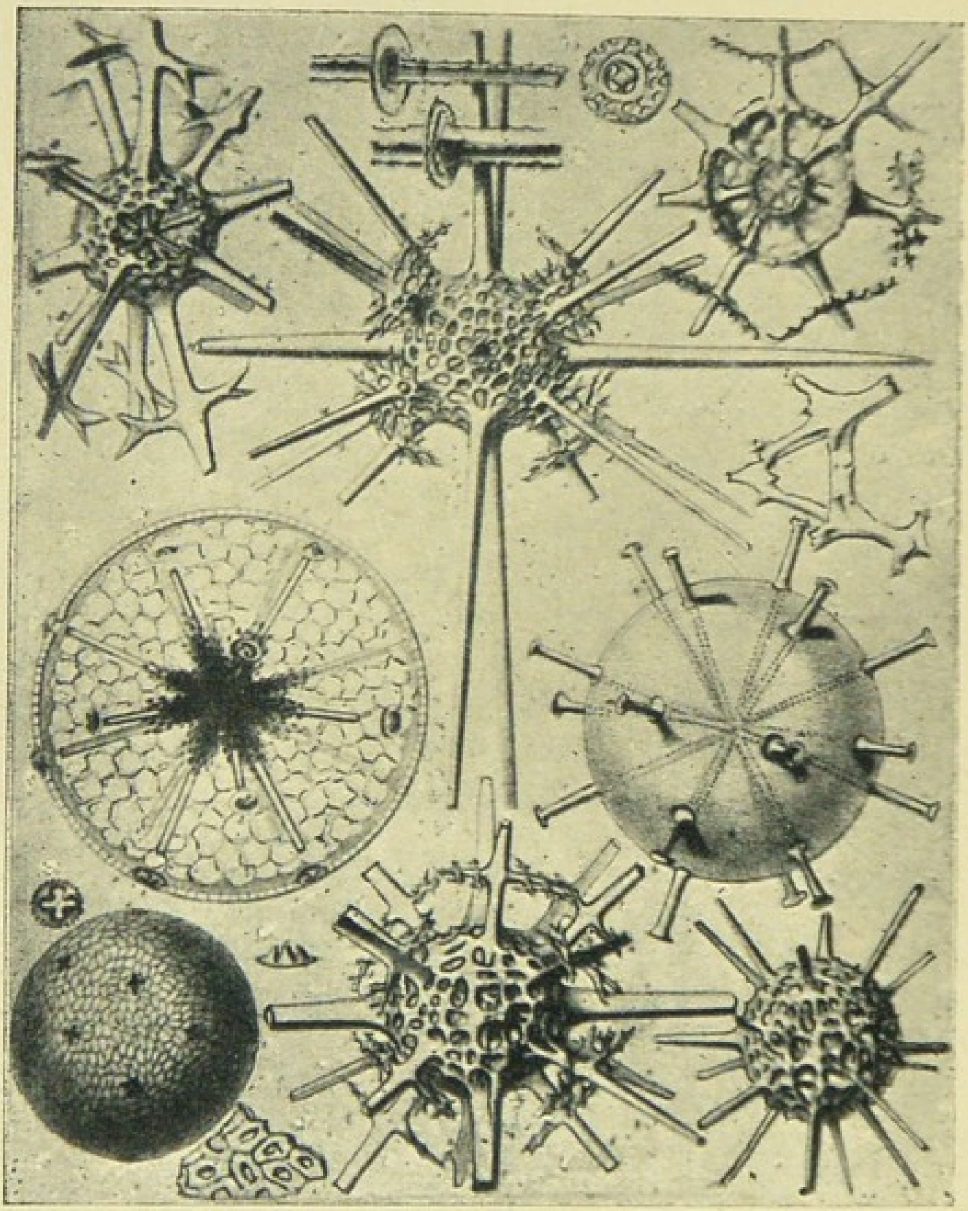

Fig. 32.—Radiolaria.
(Challenger Series.)

no knowledge, it is only reasonable to conclude that his efforts, however feeble, bear in a measure the impression or reflection of that Mind which 'hath made all things beautiful in its season.'

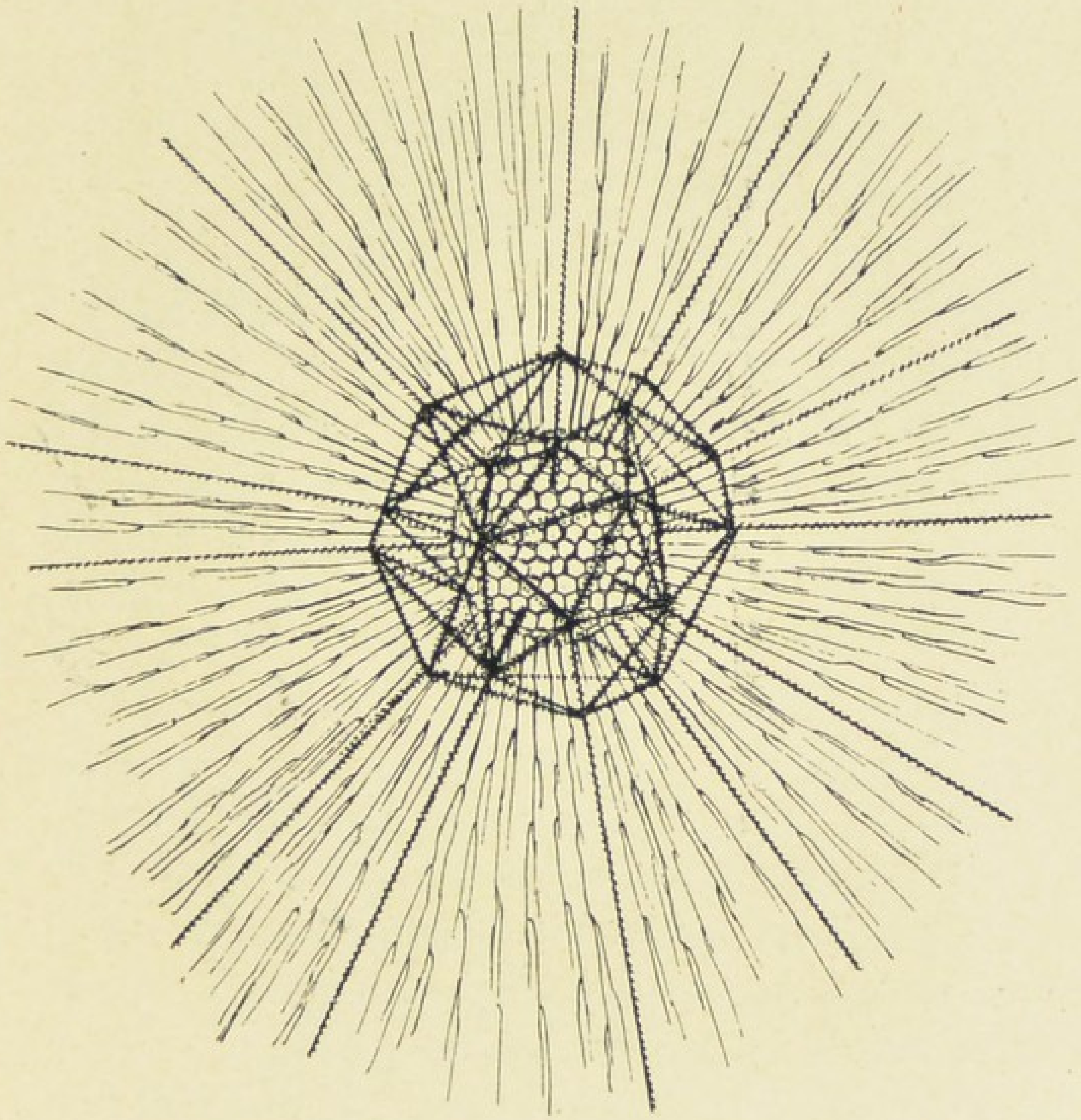

Fig. 33.—A Radiolarian. Greatly magnified.

The sections of spines of echinoderms, the patterns on diatoms, and the anchors in the sarcode of sponges, are instances noticed in these pages, in addition to those supplied by the Rhizopods, Radiolarians, and Polycystinæ.

CHAPTER IX

DIATOMS

'I AM intensely desirous that you should tell me something of the most wonderful object you have ever seen with the aid of a powerful microscope. And if the most wonderful should happen to be the most beautiful, so much the better, for the treat will be intensified.'

These words were spoken with an earnestness which was unmistakable, and which did me good to witness. The speaker was a lady, rich both as regards information and worldly possessions—two kinds of riches which do not always go together. My microscope was ready for the purpose of giving ocular demonstration and support to any replies I might make. The question was important, but only part of the response can be recorded here; because the microscope supplied nine-tenths of the answers.

As well as I can recall, the following was my share of the reply :—

'All Nature so abounds in wonderful objects full of beauty, that it would be impossible to say which deserves to be called the most beautiful. Comparisons are impracticable where the supply is unbounded. Yet there are some objects in Nature which arrest our attention more than others, and pictures of which stand out more prominently in our minds. Even the number of these appears to be infinite, and we frequently speak in anomalous terms, and say of *each member of a host* of wonderful things, "This is the most wonderful and the most beautiful object in the world."

'It is doubtful whether there exists in the animal, vegetable, or mineral kingdom, any object which embraces in *such small dimensions* so much of the truly marvellous and beautiful as the tiny plants called diatoms. So great is the fascination which attends the examination of diatoms, that men have been influenced to put aside all other microscopic studies so that they might give them their unstinted and undivided attention.'

The lady's attention being fixed, I proceeded :—

'A watchmaker of large practical experience held up between his eye and the gas flame one of my diatom slides, and well knowing that from the nature of his occupation he could focus his eyesight to a very small point, I fully expected he would discover the specimen. But he gave up the task, declaring it his belief that there was absolutely nothing on the glass slip. If these particular diatoms defy the eyesight powers of this skilled artificer, I am surely justified in pronouncing them invisible, or below the range of ordinary vision.

'Yet what are the facts? Not only will the microscope reveal this object, and show it to be beautiful, but also complex, symmetrical, and covered with a multitude of lines crossing each other in astonishing regularity, resembling the lines on the cases of some gold watches. Each variety of diatom has its own special pattern. Owing to this multitudinous crossing of lines, there are spaces between which make up devices of exquisite beauty and of geometrical accuracy.

'After viewing the diatom as a whole, we shall put on a higher power to the instrument and examine one of the intervening spaces formed by the intercrossing lines, and then we shall have an enlarged and magnificent design, only one out of thousands, on one side of the diatom! There seems to be no end to minuteness. We fail because our microscopes fail, just as the telescope cannot limit infinity. But as these are both progressive instruments

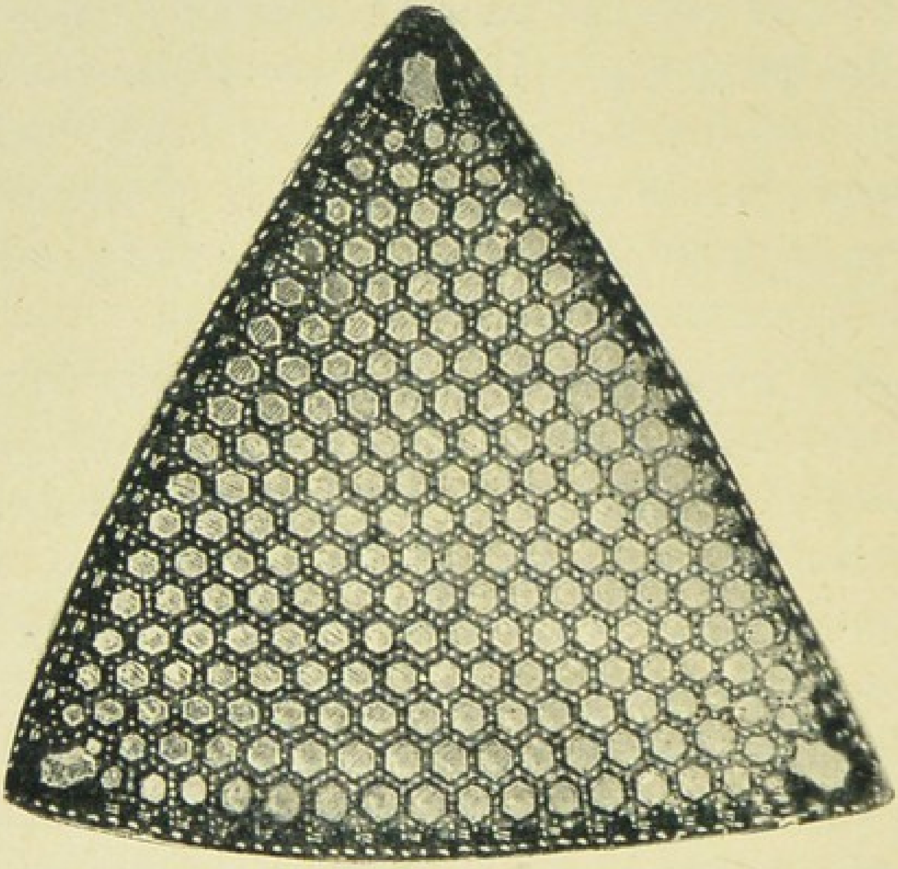

Fig. 34.—Triceratium. A Diatom enlarged several hundred diameters.

we are looking forward to further conquests in both directions—telescopic and microscopic. The end wall of this drawing-room is about twenty feet long and seventeen feet high. With the lantern we can show you a photograph of our diatom taken through the microscope.'

'Stop a minute, please,' interposed the lady; 'I do not quite follow you, for you say you photograph the diatom through the microscope. This seems as if the invisible could be brought into view. How is this done?'

'The human eye is the most perfect photographic camera in the world. In looking at the diatom through the microscope, its image is photographed on the retina of the eye. Now if we remove the eye, and in its stead we place a camera that has an extra long bellows attachment, we have only to fix the lamp so that the centre of the blaze, the diatom in position, the microscope, and the whole length of the camera are in one perfectly straight line. This is done by arranging them so that the microscope and camera lie horizontally. With care and experience even amateurs can produce very good photo-micrographs. You will observe that sunlight is not necessary in all branches of photography. This is a great advantage, because during long winter evenings photographing microscopic objects becomes a well-patronized occupation.

'The photograph of our diatom is now placed in the lantern, and we can make it appear eight, ten, or twelve feet in diameter, so that you can now see the multitude of lines and spaces and patterns I have been describing and showing to you. All the lines and possible perforations of this wonderful diatom are enclosed "within

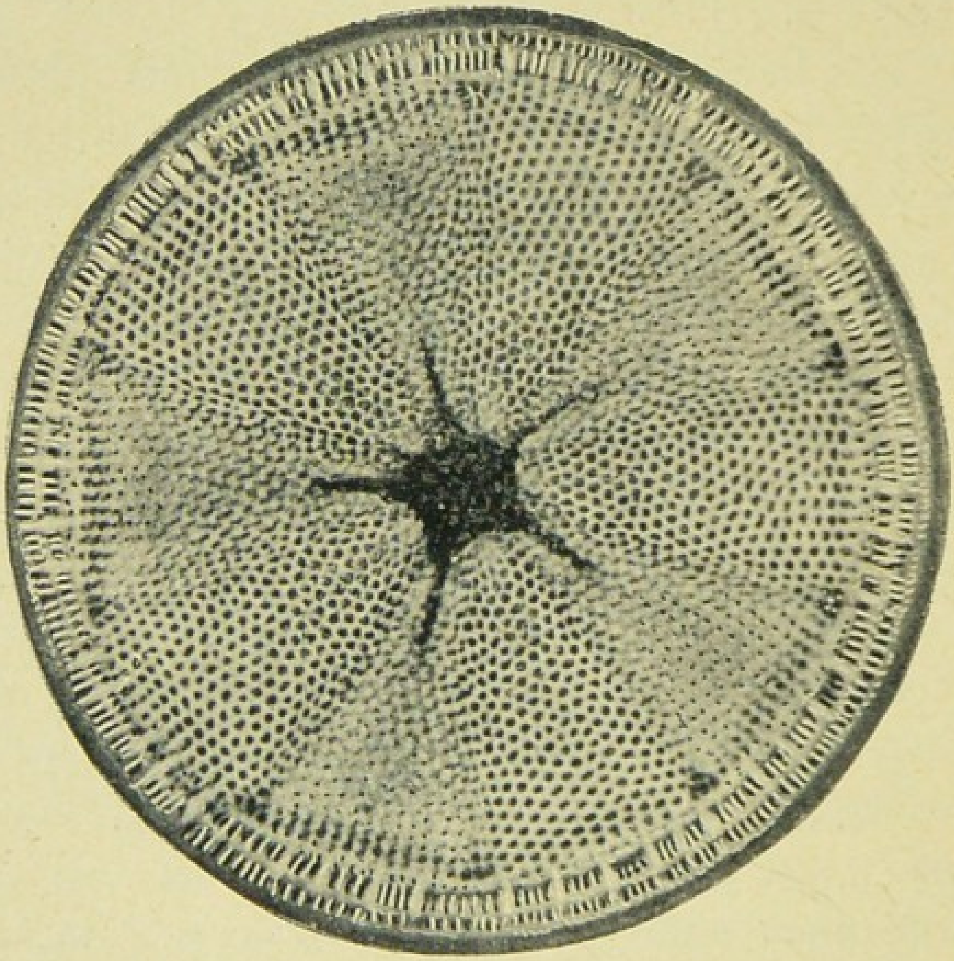

Fig. 35.—Heliopelta. Enlarged several hundred diameters.

the dimensions of a point"—a point too small to be recognised by the keen-sighted watchmaker.'

The next questions were, 'What are diatoms?' 'Are there many of them?' 'Besides drawing out our admiration and making us to feel humble, of what use are they in the great economy of Nature?'

'Diatoms are microscopic aquatic plants, found in all the fresh and salt waters of the globe that are capable of sustaining life. They are generally of a golden brown colour, and, probably owing to ciliary action, they are able to move about. Cilia are extremely fine lashes, which cannot be seen unless with extraordinary high powers. They prevail in all departments of life.

'Each diatom, in addition to its vegetable structure, possesses a beautiful flinty box, having a lid, bottom and rim ornamented in the manner described. And as there are thousands of kinds of diatoms, so there are thousands of shapes assumed by their respective boxes. Some are round like a pill-box, some are triangular; others are boat-shaped; while some have four corners, others have seven, and so on. All are marvellously decorated. To purchasers of microscopes they are of immense service, in that their fine lines are tests and guides as to the power and accuracy of the instruments from which they are selecting.

'But there is a still grander use for diatoms.

When the vegetable portions die, the flinty structures form a deposit on the floor of lake or sea, which in time attains to a thickness of several feet. Still more time, and these deposits become compact rocks, and thus the flint (silex) before extracted from the waters by living diatoms now forms a part of the solid structure of the earth. Diatoms furnish us with evidences of a wisdom far beyond anything we can comprehend. That such a little box, so small that it cannot be recognised with the unassisted eye, should contain an orderly arrangement of multitudes of lines, is of itself a thing quite beyond our mental grasp. All diatoms are not so small as the special varieties we have been examining; still, they are all microscopic. Many of them appear to be as small as the dust in the sunbeam.'

This ended my conversation with the lady, but neither this account nor any single sketch can do full justice to the subject.

At a recent conversazione of the Royal Society, Mr. Joseph Goold exhibited a twin-pendulum of the most simple construction, which delineated an endless variety of beautifully-curved figures, the result of a certain law inseparably connected with music. So splendidly did the pendulum trace out the attractive designs, that we found it a difficult matter to get away to study the other exhibits. Looking on with admiring appreciation was Mr. Perigal, F.R.A.S., a gentleman whose marvel-

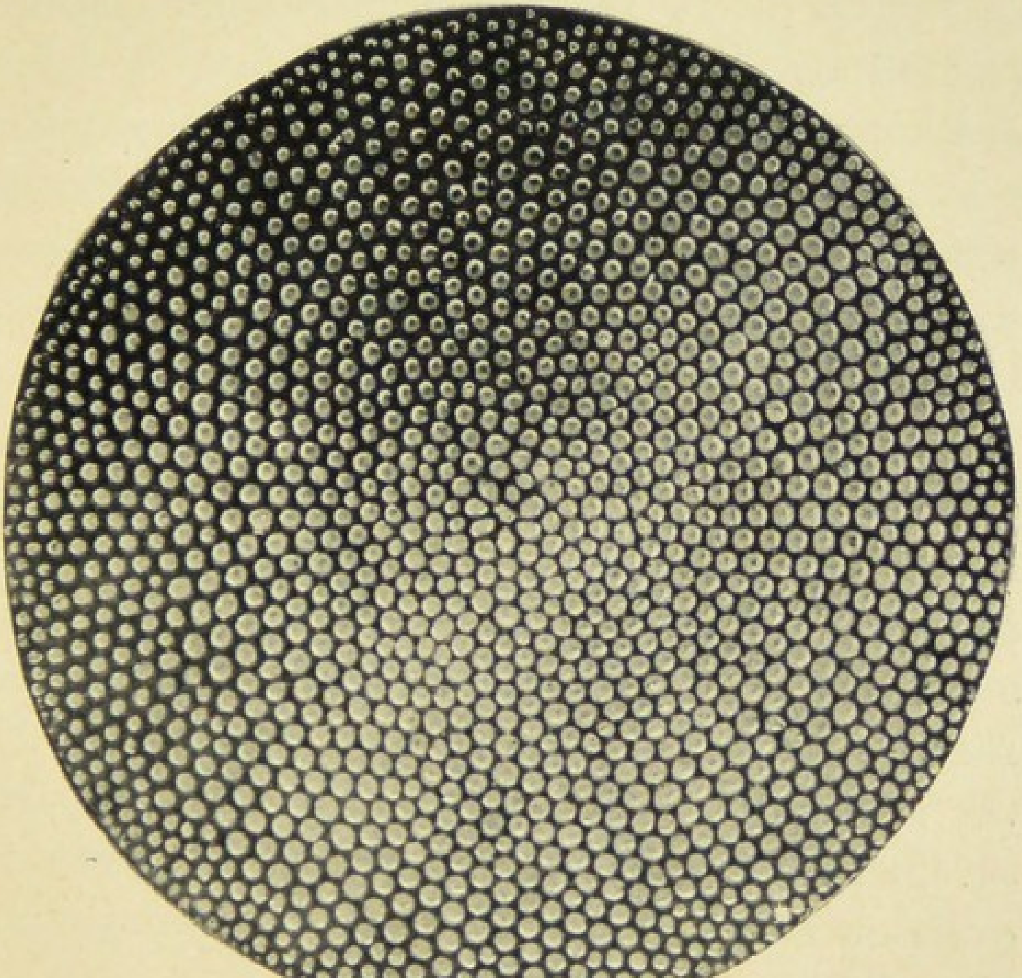

Fig. 36.—Coscinodiscus radiatus. A Diatom enlarged several hundred diameters.

lous power of complex curve-making used to astonish every one who saw his work. So closely did Mr. Perigal's handiwork resemble the tracery done by the harmonic pendulum that one was frequently mistaken for the other. The results in each case were enclosed within an area of a few inches.

In addition to patterns and devices thus produced, there are the charming designs accomplished by the geometric chuck and by other mechanical contrivances. But while we feel great admiration for the splendid works to which we have referred, and of which we have specimens we value exceedingly, yet Nature very easily 'puts them all into the shade.'

A simple diatom from Thames mud far outdistances the pendulum, the bow-compass, the lathe, and other mechanical contrivances. A sample of guano imported from South America, and no larger than a marble, will contain thousands of diatoms, any one of which will baffle the power of a genius to imitate. Certain parts of Sheppey Island mainly consist of the triangular forms of diatoms shown enormously enlarged as fig. 34.

Suppose we take a sheet of paper, and by very accurate work we draw upon it two lines only one-hundredth of an inch apart, we can just distinguish the enclosed white line. Now, to produce a set of lines so close as to represent the lines on some diatoms we should have to divide this space of the one-hundredth of an inch into 520 spaces. In other diatoms we should have to divide the hundredth into 940 spaces.

The diatoms in the illustrations are about on the borderland of our vision.

Although our eyes may see, when aided by microscopic power, the minutely complex but orderly system of lines and spaces on the surfaces of these flinty atoms, yet our keenest perceptions become exhausted in the effort to grasp a fixed idea of what we are actually beholding. We see, but we have a certain difficulty in believing. For a time we question the existence of such a possibility, and we finally conclude that we are on the threshold of an infinity in microscopy as great as that which confronts the devout astronomer when studying the realms of space.

The microscope enables the geologist to study the rocks of the globe, so that he can show that whole districts of Istria and Dalmatia consist of diatoms; that these flinty boxes contribute largely to the composition of the rocks of a recent geological formation; that lake deposits several feet in thickness exist in Australia, that the soil of large tracts of Austria, near Bori, is almost exclusively flinty boxes of diatoms; that the city of Richmond, in the United States, is built upon an eighteen feet stratum of fossil diatoms.

The seas and freshwaters of the globe contain countless millions of diatoms; they are to be found in every country of the world.

The hoardings of our cities advertise in large characters myriads of diatoms for sale; only substituting for their correct name the words 'knife polish.' Many a man has more diatoms in his scullery than he can examine and mount as microscopic objects, even if he should devote a lifetime to the task.

England has become possessed of other countries in various ways and by a variety of means, but none of her actions were so subtle as those now employed in acquiring South America, for we are daily purchasing, in shilling or sixpenny packages, the soil of the pear-shaped continent. Ostensibly we use it above board (*i.e.* the knife-board) as knife polish; but we are keeping it to augment our soil, and it is only a question of time to see it all conveyed to our shores.

The men who make the microscopic study of diatoms their hobby are rudely termed 'diatomaniacs.' Yet there are few studies more fascinating, or that so well repay for any trouble expended upon their individual examination. Some of the greatest men in England, America, France and Germany are skilled diatomists. Although these tiny plants are so insignificant apparently, yet large volumes have been written about them, and the highest art has been brought to bear upon the illustrations which are used to make their study easy and attractive. But no illustration and no word-painting can at all compare with a five minutes' peep through a powerful microscope, when a group of diatoms is in view.

The astronomer tells us that, so far as is known, the outermost planet of this system is Neptune; that it travels more than three miles every second; that it takes, even at this rate, 165 years to complete one revolution around the sun; that, in fact, it is now (1895) only arriving at that point in its orbit where it last was in the third year of George the Second (1730). The effort of thinking power required to lay hold on such a statement is unattainable by most people, if at all by any one. But the distance of this planet is a mere trifle to those which the astronomer deals with if he proceeds to speak of 'fixed stars,' so called. We very soon lose all control over the imagination, and we become lost in infinity. Even so, it seems more possible to come face to face with infinity in the great outer space, than to form any conception of infinity as regards the minute side of creation. Few objects bring home to us more effectively the limits of imaginative power than do the diatoms.

CHAPTER X

EGGS OF INSECTS, ETC

FOR years we were dependent upon the taste and genius of our continental neighbours for artistic patterns and devices required in our trades and manufactures. We are now learning to lean more upon Nature, and to take hints from her inexhaustible displays of beauty and symmetry, and from her arrangements of colour and of light and shade. Consequently, as a nation, we are becoming more artistic, and our surroundings show a decided advance beyond anything known two generations back.

The artistic compositions of the ancient Egyptians, Persians, Hindus, Chinese, Japanese, Greeks and Romans were all interspersed with animal or plant forms, and although many of their designs were grotesque and conventional, yet they form some of the richest treasures of the British and South Kensington Museums.

The leaves and flowers of plants, by their gentle undulations, delicate outlines, and graceful curves, are a prolific source of help to scores of artificers in wood, iron, gold and silver.

It needs but a moment's consideration to see that Nature yields a boundless variety of combinations and devices, useful in thousands of ways, and that, as a rule, her beauties are only hidden from those who will not make the effort to see them. But when we turn to the microscopic forms of life, we are astonished that so much beauty should be accorded to objects so small, and so apparently unimportant, and we marvel at the loveliness hidden in a mere speck and only made visible by a powerful magnifier.

It may be that these wonders of Nature are intended for our study, to teach us the importance of being accurate, and that in them we may have before us at all times the handiwork of God and evidences of His wisdom.

Leuwenhoek (1632–1723) states that in three months a single house-fly can produce 746,496 eggs; and Linnæus, calculating on the voracity of the hungry offspring of a fly, states that, in warm climates, three flies destroy the dead body of a horse as quickly as a lion. According to Sir Richard Owen it requires nineteen figures to express the numerical offspring of a single aphis in the tenth generation. Notwithstanding the extraordinary fecundity of insects their eggs are marvels of beauty. But to our limited vision the human eye only sees the general shape and colour of these tiny objects. Let them be viewed with the aid of the microscope, and at once their delicate chisellings and mechanism appear.

Some insects lay oval eggs, others cylindrical, others spherical. Some eggs are like Grecian water-bottles, others have crowns on the top. Some have rims, grooves, and projecting points of ornamentation. In some the lines around the exterior entwine in beautiful order, in others lines and flutings prevail, as if they had just come from the hands of a skilful engraver. A fine lace covering envelopes the surfaces of several insects' eggs. Many are tinted and coloured, while others display an iridescence surpassing that of the ear-shell, haliotis. Even the eggs of the parasites of birds are more splendid than the eggs of the birds themselves.

In support of this statement the reader may be referred to *Science Gossip*, or to the recent edition of *The Microscope and its Revelations*, by Dr. Carpenter, revised by Dr. Dallinger. It will at once be apparent that such eggs as are figured, especially those in *Science Gossip*, possess a very high degree of beauty. Microscopic objects, such as eggs of insects, many of which range between the fiftieth and the hundredth part of an inch in diameter, cannot appear, either to our judgment or to *unassisted* vision, to possess any surface on which it is possible to display any ornamentation.

If superficial space be allowed, we can understand the presence and the possibility of decorative beauty; but when objects are so small that several of them, if tied together, would readily fall through the eye of a fine needle, we are naturally astonished and puzzled to find them ornamentally embossed and beautified in the highest degree.

Thirty, forty, or even fifty rows of bead-like prominences, and hundreds of transverse lines, forming a net-like appearance, may be seen on the surfaces of many insects' eggs when placed under microscopic power.

The writer upon microscopic forms of life and beauty is always placed at a great disadvantage, and labours under difficulties not experienced by those engaged upon other departments of Nature. His subjects are so small, so far below the range of eyesight, that he cannot convey, by any language he may use or any illustration at his command, any impression at all approaching that experienced by one look directly at the objects named.

Many of the eggs of insects are exquisitely fluted, others are ribbed. There are some insects' eggs which have a lid at one end, which the young caterpillar pushes open when he introduces himself to insect society. For it must be remembered that all responsibility on the parents' part ceases when the eggs are deposited.

There is no parental hatching nor after-care for the young, as in higher orders of life. It is true that the parent insect almost invariably selects, when depositing its eggs, surroundings that will be congenial to the young the moment they are born, localities where warmth and food are guaranteed. To ensure both these results, certain insects lay their eggs in the dead bodies of other creatures, hence the larvæ become useful scavengers.

Each kind of butterfly or other insect has its own special form of egg so distinctly marked that an entomologist should be able to name the insect by merely seeing its egg.

The eggs of certain butterflies are so wonderfully ornamented that in point of design they stand pre-eminently before the eggs of birds. The egg shells of butterflies consist of a tough gelatinous substance which resists fairly strong acids. They differ from those of birds in that they contain no carbonate of lime. There is another circumstance connected with their history which deserves especial notice. The

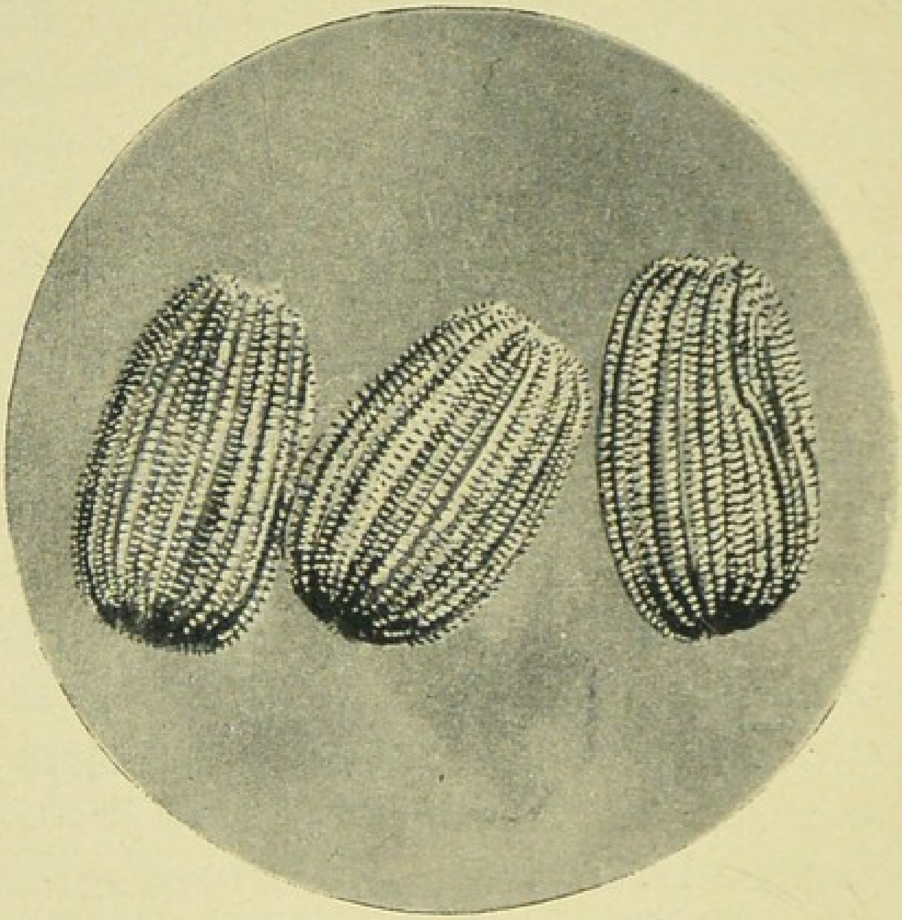

Fig. 37.—Eggs of a tiny Moth. Enormously magnified.

vitality of the eggs of butterflies and moths is not impaired by exposure to extreme cold.

They may be frozen in a block of ice, and in due time they are hatched, as if nothing unusual had occurred. Were it otherwise, a severe winter would bring about the destruction and extinction of hosts of some of these most beautiful creatures.

Although these eggs are microscopic, yet the same protecting care is bestowed upon them that is extended to the eggs of the guillemots of the cliffs for their protection, though in a different manner. This bird lays but one egg in the season, and as it is placed on a narrow ledge of rock at a considerable height, if shaped like a hen's egg, it would roll off, and the guillemots would soon become extinct; but these eggs are tapered to a point, so that when they are disturbed by the birds themselves, or by the wind, they rotate around the narrow end, and cannot wobble off. Instances of protecting care like this are continually making themselves apparent, and we are not justified in attributing all to the work of a blind chance. Hosts of tiny crea-creatures, glittering in the sunshine, were born this morning at sunrise. At noon they will attain to middle life, at sunset they will die of old age. Do they not teach us a lesson?

'Poor insect, what a little day
Of sunny bliss is thine!
And yet thou spread'st thy light wings gay,
And spreading, bid'st them shine.'

The poet, looking at the insect life from the egg until it arrives at the imago or perfect stage, exclaims :—

'Which the tomb a willing guest descends.
But when revolving months have won their way,
When smile the woods, and when the zephyrs play,
When laughs the vivid world in summer's bloom,
He bursts, and flies triumphant from the tomb ;
And while his new-born beauties he displays,
With conscious joys his altered form surveys.'

Well might the poet add :—

'And deems weak man the future promise vain,
When worms can die, and, glorious, rise again ?'

Making allowance for the poet's lack of scientific accuracy, in that the creature does not actually die, the sentiment is good.

The creature that in its early stages of life crawls along the earth as a grub, and that as a perfect insect comes up into the sunshine, and unfolds its beauteous wings in the light of God's glorious day, is to some a type of human life in its earthly and heavenly conditions, and supplies us with hopes of a future state. This may not be accepted by every one, yet all must admit that, however hard life's struggle may be, the fact that Nature abounds in things so beautiful, so fair, and so enchantingly attractive, tends to make that struggle easier, and cheers us in our pilgrimage whether we admit or do not admit that God is the Author of Nature.

The sweet influences of the presence of butterflies, of flowers, of gorgeous colours, of the song of birds, and of delicate perfumes, are luxuries and blessings without which our lives would be sombre indeed.

CHAPTER XI

FORAMINIFERA

THE majority of the shells of the Foraminifera (Lat. *foramen*, an aperture; *fero*, to bear) have numbers of tiny openings throughout their whole surface, so that the finely extended feelers or pseudopodia (Gk. *pseudos*, false; *pous*, foot) may protrude in any direction. We must not, however, imagine that the tiny creatures have definite feelers or false feet, for they are simply extensions of the sarcode, similar to those of the rhizopods of fresh water, described in chapter XII.

These marine rhizopods constitute by far the most important order of this class of life. This will be apparent if we take into consideration the vast quantities in which they have existed from very early times, and from the enormous extent in which their remains have contributed to the formation of rocks. Most of them live on the bottoms of oceans and seas, creeping on the seaweeds, dead shells, and corals, and are food for sponges and other creatures. Large numbers, however, live on the surfaces of oceans and seas, their dead shells continually descending to the

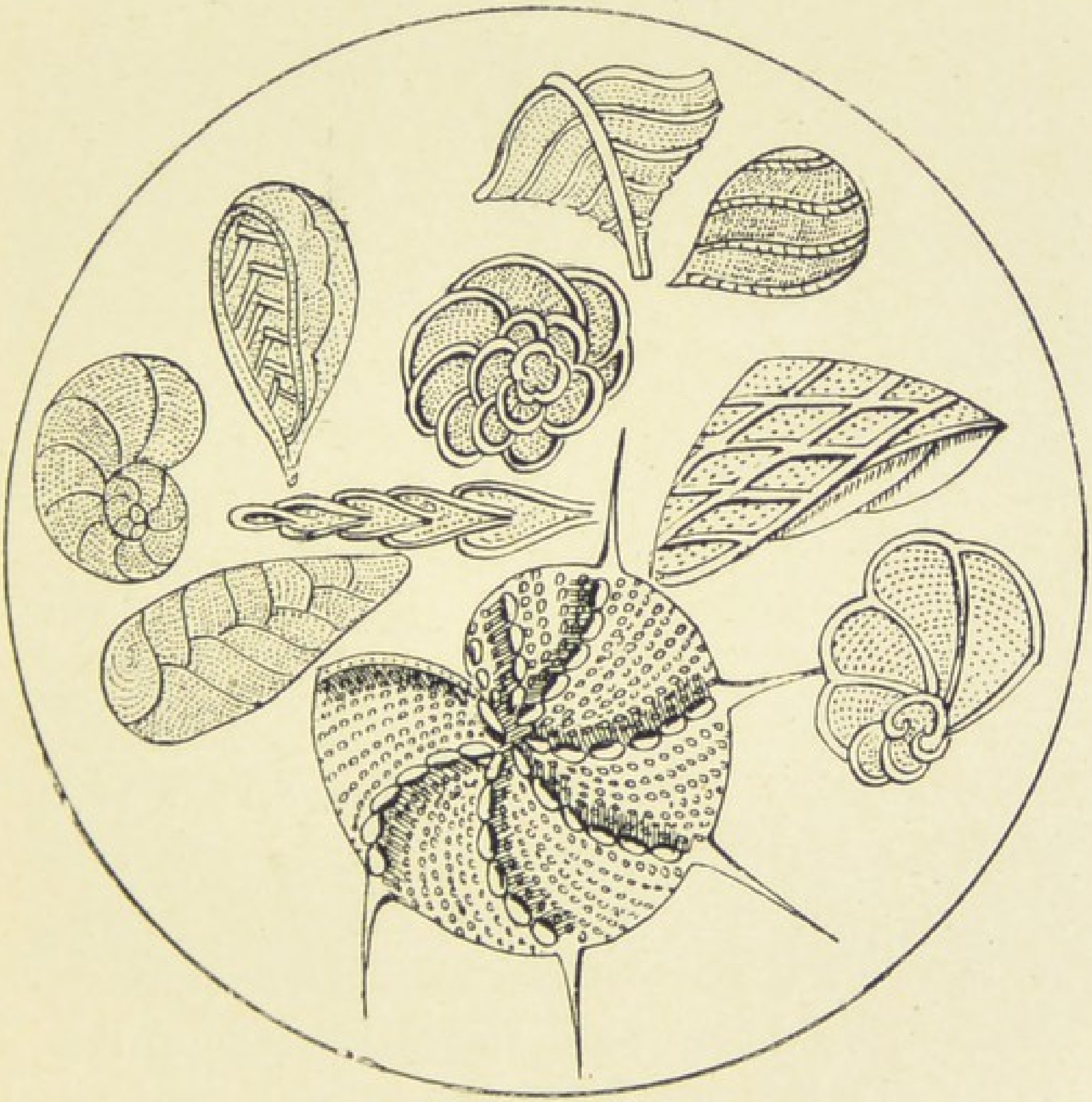

Fig. 38.—Foraminifera. Greatly enlarged.

depths below, where they form ocean mud, as in the case of those noticed under the heading, 'Atlantic Ooze.' The globigerina there described form one of the many classes of marine rhizopods, and are in reality a group of Foraminifera.

Though generally too minute to be distinguished by the naked eye, the Foraminifera are readily detected with a good pocket-lens.

In the warmer waters of the oceans they attain a greater size than towards the poles. They reached a much greater size in remote geological times, so that fossil forms are much larger than those now living.

This will be apparent to you if you should have an opportunity of seeing a piece of the limestone used by the ancient Egyptians to rear the Pyramids. This rock consists of shells of Foraminifera, and the coin-shaped fossils it contains are called nummulites (Lat. *nummulus*, a small coin). The Pyramids, doubtless, are a gigantic work, yet they are only a very small portion of the mud of an ocean floor of early ages, and form part of the rocks known as the Tertiary, which extends along the South of Europe and Northern Africa into Asia. All this immense formation is the outcome of Foraminifera having lived in abundance in the waters of an ancient ocean which must have existed in this part of the world.

We must concede, therefore, that the Foraminifera of the past were of vast importance in carrying out the Creator's plans; for the nummulitic limestone alone attains to a thickness of several thousand feet, and contributes

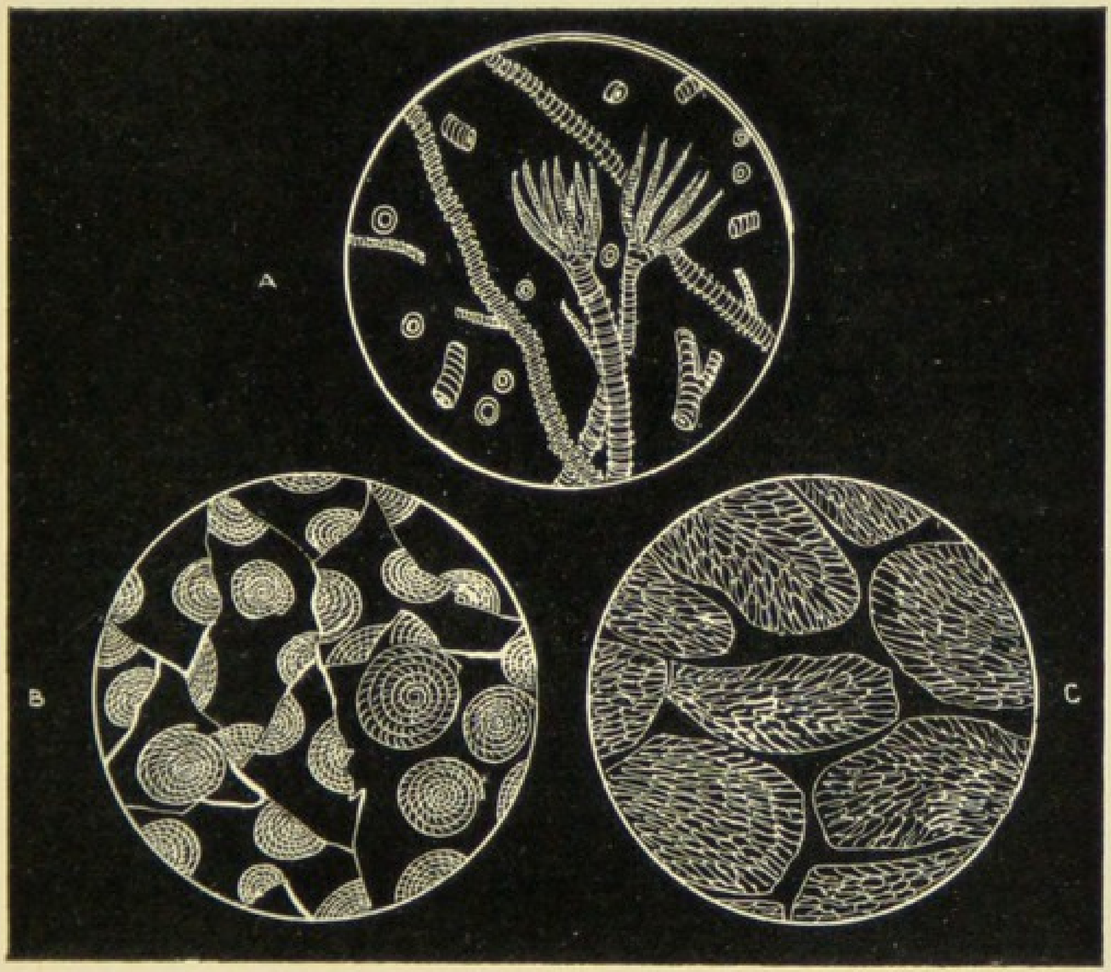

Fig. 39.—*A* Encrinite Limestone. *B* Nummulitic Limestone. *C* Coralline Limestone.

largely to the formation of the Pyrenees, Alps, Apennines, Carpathians, and Himalayas, and extends through the Mediterranean basin, Asia Minor, and Persia, into India.

Most of the shells of the Foraminifera are made up of calcareous or chalky matter, which the organisms secrete from the surrounding sea water. Some, however, have shells that are partly calcareous and partly thin particles of sand. There are also those whose shells are entirely made up of sand-grains cemented together.

Notwithstanding their minuteness, with few exceptions, the shells are partitioned into many chambers. Picture such a complex structure in a shell sufficiently small to drop through the eye of a needle! Many of the forms of shells are spiral, and are like those of the nautilus and ammonite. Some Foraminifera shells are so small that 280,000 of them have weighed but one ounce! This opens up a subject for the exercise of our minds.

The chalk of Europe is the result of foraminiferal life, as are also many of the so-called greensands. Many of the rocks of earlier ages than those yet mentioned, namely, the carboniferous limestones, consist of shells of Foraminifera, notably that known as 'fusilina limestone.'

In the chapter on 'Atlantic Ooze' we see that the building-up process is progressing at the present moment, and what is taking place in the Atlantic occurs in other oceans and seas. The families of the Foraminifera may be different, but their agency is incessant and almost universal. We ought not, therefore, to find any difficulty in obtaining samples of these beautiful shells for examination. Beauty, and that in a high degree, characterises all the shells of the Foraminifera, whether recently found floating on the ocean surface, or forming an integral part of some limestone rock.

I can imagine some young friend saying, 'I should like to see the Foraminifera shells from the floor of the further end of the Mediterranean Sea, but I have no means of getting a supply.' It can be managed in this way, for you do not require a cartload. A sample that will cover a sixpence will be sufficient for microscopic examination. Go to a chemist, or any dealer of sponges, and get him to shake a new sponge on a sheet of paper. You may find a good supply of sand, but you are sure to meet with the object of your search. If the contents of the paper be put into water, the Foraminifera will float. Specimens of deposits from all ocean floors may be had at any of the reliable mounters of microscopic objects.

The postal arrangements are so simple now that there need be but little delay or difficulty in getting samples of rocks from any of the great formations of the globe. Any practical geologist would give instructions as to the way in which any specimen can be obtained and prepared, in order to show the hidden beauty of their structure to perfection.

If the Eozoon Canadense of the Laurentian rocks belonged to the Foraminifera, these creatures must have been amongst the very earliest inhabitants of the earlier waters of the globe. But as the animal nature of Eozoon has always been a matter of doubt with many eminent naturalists, we have only to refer to the other rocks previously mentioned for evidence of the very remote appearance of the Foraminifera as elevating agents of an almost universal character.

The exceedingly simple structure of the creature itself, apart from its shell, is a matter of surprise to all who have observed them under the microscope. Scarcely anything can be noticed but a jelly-like substance termed 'sarcode,' or rudimentary flesh. In fact, no difference between the amœba, the sarcode of a rhizopod, and that of the Foraminifera can be detected, however high may be the microscopic power employed. This is the point where science is baffled. The biologist sees the three forms of sarcode, but he has not the faintest idea as to which one will appropriate the silica, or which the carbonate of lime, or which will decline both of these substances. The microscope detects no difference, chemical analysis fails to say which has this or that power. They are only specks that are under examination. They are devoid of organs, yet they are as distinct as possible in the mysterious powers they possess. Place them in their proper elements. One feeds, but assimilates neither the flint nor the lime held in suspense in the water, so that it does not secrete a shell; another appropriates in a very marvellous manner the flinty matter, and lo! a most complex structure, perforated, latticed, ornamented, and of surpassing attractiveness, is the result; the third has no power over the silica, but instead it selects the carbonate of lime, and a beautiful shell is produced. This mysterious principle, force, or whatever else we may call it, is not a chance possession. There is nothing haphazard about this, any more than there is about the uses of the moon to this earth. This is only one of the innumerable phases of life that puzzle men of science—and that can only be answered by attributing all to the general plan of creation which in every stage shows overwhelming evidence of the existence of an all-wise God.

In addition to those Foraminifera which take in calcareous or chalky matter, there are some members of this group that have not this power, but, instead, lay hold on particles of sand and fragments of shells, spicules, diatom cases—in fact, anything that is adapted for building purposes, and with these they are able to make splendid homes or cases. In pond water the 'caddis' resorts to a similar method.

This particular class of Foraminifera is splendidly figured and described in Brady's monograph, which forms one of the Challenger Reports. The shells or coverings so constructed are beautiful, both as regards the selection of materials and in the designs embraced. As the materials are not secreted by the Foraminifera of this class, the shells are said to be *extrinsic*, as instanced in the freshwater rhizopods. Thus we see some points of resemblance between the microscopic organisms of sea water and those of fresh water. It follows, too, that the nature of the shells, if extrinsic (*i.e.* made up of materials found on the ocean floor, such as particles of sand, etc., as already stated), must entirely depend upon the nature of the remains scattered on the bed of the ocean. Hence, as these materials are very varied, the shells themselves are varied in texture and colour. And as all these creatures have not equal powers, the shapes of their shells are greatly varied.

One could spend hours looking at the illustrations alone of these marvellous Foraminifera in the work just mentioned. But the objects themselves are much more enchanting, as must always be the case in depicting forms of microscopic life.

CHAPTER XII

FRESH-WATER RHIZOPODS

THE rhizopods[1] (root-footed creatures) are among the simplest and lowest forms of animal life. They are mostly minute, rarely visible to the naked eye, and always require the high power of the microscope to bring out the beauty of their structure. The greater number of them construct shells of rare outlines and of great variety. Their soft parts consist of a jelly-like substance, which is capable of being extended in thread-like processes, to be used as meshes of prehension or as organs of locomotion. The minuteness of these creatures is compensated for in their numerical strength and their world-wide distribution. They are all aquatic, occurring wherever there is moisture.

Every dyke, pool, pond, sea, and ocean abounds with rhizopods, and it is doubtful if

[1] Gr. *rhiza*, a root; *pous*, foot.

in the economy of Nature any other class of animals exceeds them in importance.

Geologists tell us that rhizopods were the starting-point in time of animal life, and that their agency in the construction of many rocks of the globe has not been equalled by that of higher or more visible forms. We cannot go lower in the scale of animal life. The rhizopod is the simplest of simple animals. It has no internal cavity like the body-cavity of higher animals; it has no mouth, neither has it a stomach, nor a trace of an intestine. It is devoid of a nervous system, and possesses no fixed organs of any kind. Its negative possessions, to use an Irishism, are far in excess of its real ones, reminding us of Sydney Smith's remark to a person boasting of his own knowledge: 'All you don't know would fill a very large book.'

The rhizopod is a mere speck of jelly or sarcode (Gr. *sarx*, flesh; *eidos*, form), yet it moves about with the apparent purposes of more complex creatures. Of these creatures the late Professor W. B. Carpenter remarked :—

'Laying hold of its food without members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves. . . . And not only this, but in many instances forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animals,' *i.e.* animals that have shells.

Most members of this extensive group of tiny organisms are, as we have already said, provided with a shell or home of hard material. In the majority of instances the shell consists of hardened parts of the animal substance, a something which pertains to the inherent structure of the animal itself. The shell is then said to be *intrinsic*.

But frequently we find rhizopods possessing a power that enables them to appropriate flinty particles, transparent quartz sand, diatom cases, and sponge spicules, and to collect and fashion into artistic pellets the clay in the surrounding water with which to make their shells or cases. In such cases, inasmuch as all the materials are collected from external sources, the shells are said to be *extrinsic*.

It will be well to thoroughly grasp these two definitions, because they form the basis of all our knowledge of rhizopods, whether of fresh or of sea water, and it is in connection with the shells that we shall observe the hidden beauty we are seeking. There is scarcely a class of animals in the whole range of the animal kingdom about which such divergence of opinion has been held.

Dozens of naturalists have studied them in the endeavour to arrange them into species and genera, but the absolute distinctions which appear more definitely to characterise the higher forms of life are absent in the rhizopods. The members of this class of life are infinitely variable, and therefore impossible to classify completely.

For the present we wish to notice those creatures that have shells and that live in fresh water.

The ponds and lakes of all latitudes contain rhizopods, and they are found at all levels, from that of the sea to a height of ten thousand feet in the Rocky Mountains. There need be no difficulty, therefore, in obtaining specimens for examination.

Whenever the ground is sufficiently damp for the growth of algæ there will also flourish the rhizopods. They occur on the dead boughs of trees submerged in water, and on the stems and leaves of aquatic plants. They are found in profusion in bogs and marshy ground, where bog-moss, or *sphagnum*, grows. If the water squeezed out from *sphagnum* be examined, it will be found to contain hosts of exquisite specimens. Hence, if wet samples of this bog-moss be collected in preserving pans, and renewed occasionally with water, the supply of rhizopods may be kept up for a considerable time.

To examine rhizopods it is best to tease out the mosses, and to press the water from the pulpy mass into a watch glass. A drop of the sediment is then sufficient for placing under the microscope.

If we look at fig. 40 we shall see drawings of a set of rhizopods known as Difflugia.[1] In each case the material for the shell is obtained from external sources, and is fashioned in a definite shape. The first three on the top row, beginning from the left, are each the hundredth of an inch in diameter! The next two are smaller; their diameters are only the hundred and twenty-fifth of an inch, while the last, amphora, a name it well deserves, is the hundredth of an inch. All but the last on the bottom row are each only the two hun-

[1] Lat. *diffluo*, to flow.

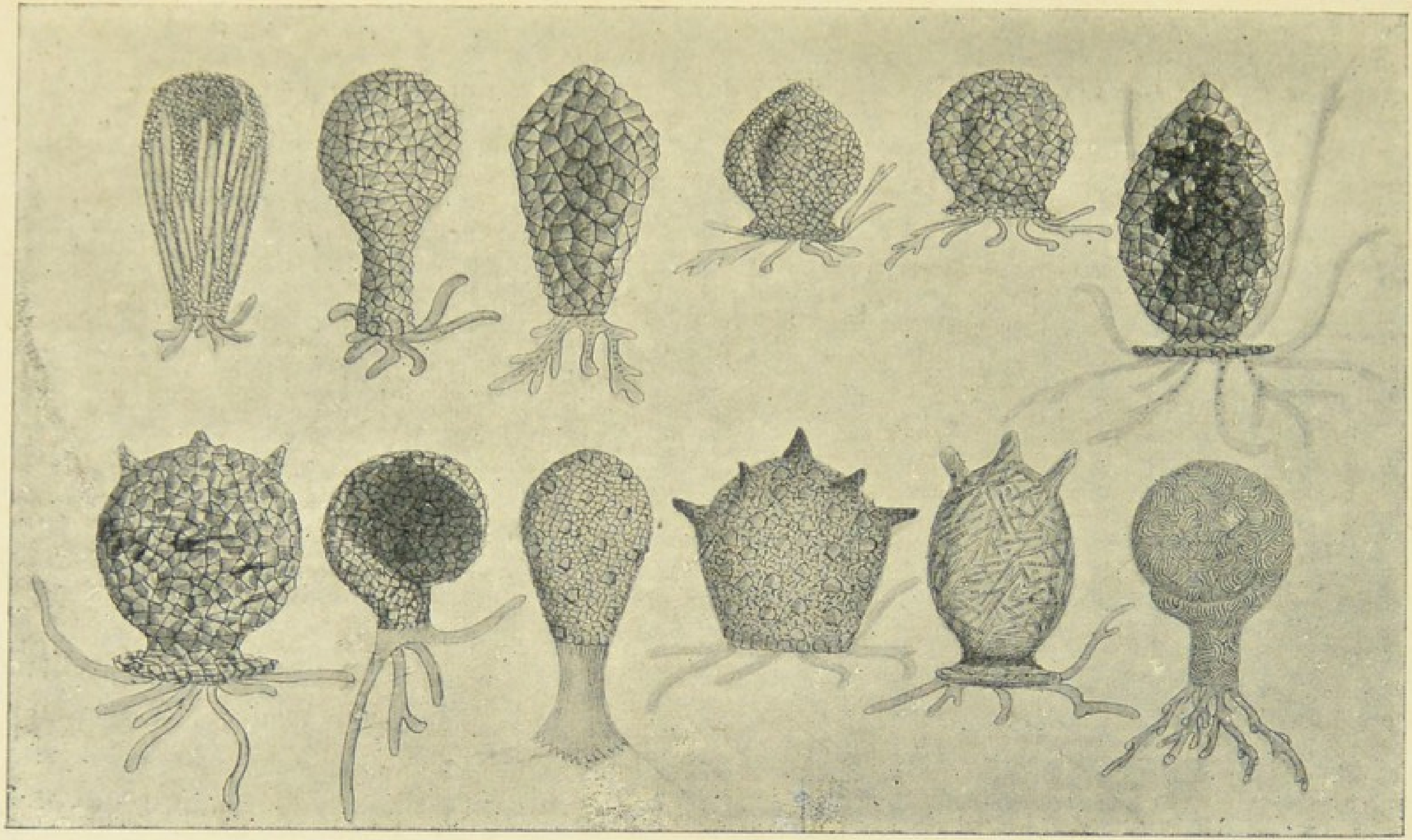

Fig. 40.—Difflugia, Fresh-water Rhizopods (after Leidy). Ranging from the $\frac{1}{100}$th to the $\frac{1}{250}$th of an inch in diameter.

dredth, and the last the two hundred and fiftieth of an inch. Grains of transparent quartz sand make up the shells of nine of these figures. That of the first is quartz sand mixed with diatom cases (see chapter on Diatoms). The shell of the eleventh is made up entirely of diatoms, while that of the twelfth is entirely composed of pellets of clay. Here are vases, water-bottles, gipsy crocks and amphoras, so small that we require a microscope in order to see their beauty.

Let any student of practical geometry take his compasses and ivory scale and let him mark off on a sheet of paper the dimensions of these vases, ranging from the hundredth to the two hundred and fiftieth of an inch, and show the spaces in which they could be arranged, and it will dawn upon his mind that the fashioning of these tiny homes is something beyond our knowledge and power to fathom.

We have observed that, so far, the shells of many of the Difflugia are made up of substances exterior to the creatures themselves, and are therefore *extrinsic*.

Dujardin in 1837, Ehrenberg in the following year, also Carter and Dr. Wallich, studied and described several forms of Difflugia. They found that the outer covering of the smallest specimens consist of chitinoid membrane, a substance closely allied to the hard covering of insects, and that the larger forms were able to appropriate extremely small particles of quartz sand and other materials, with which they covered themselves in most artistic fashions. Notwithstanding that both these families of Difflugia occupy the same sphagnous swamps, their coverings were quite different. They can be found everywhere in the ooze of ponds, bogs, and ditches. Their life-history is unknown, so that here is an opportunity at hand for some patient student of Nature to study their cycle of life, their habits and their usefulness in the great range of natural wonders. All that is known of these remarkable forms of life may be summed up in a few words. Many of their different subdivisions are known, and points of difference in their colour, and shapes are familiar to students of this department of microscopic life—their measurements, although extremely minute, are tabulated; their habitat, kinds of coverings, and a few of their peculiarities have been studied by just a few naturalists, probably not more than ten. Many more points in their history must be made out before we can say we thoroughly know the Difflugia.

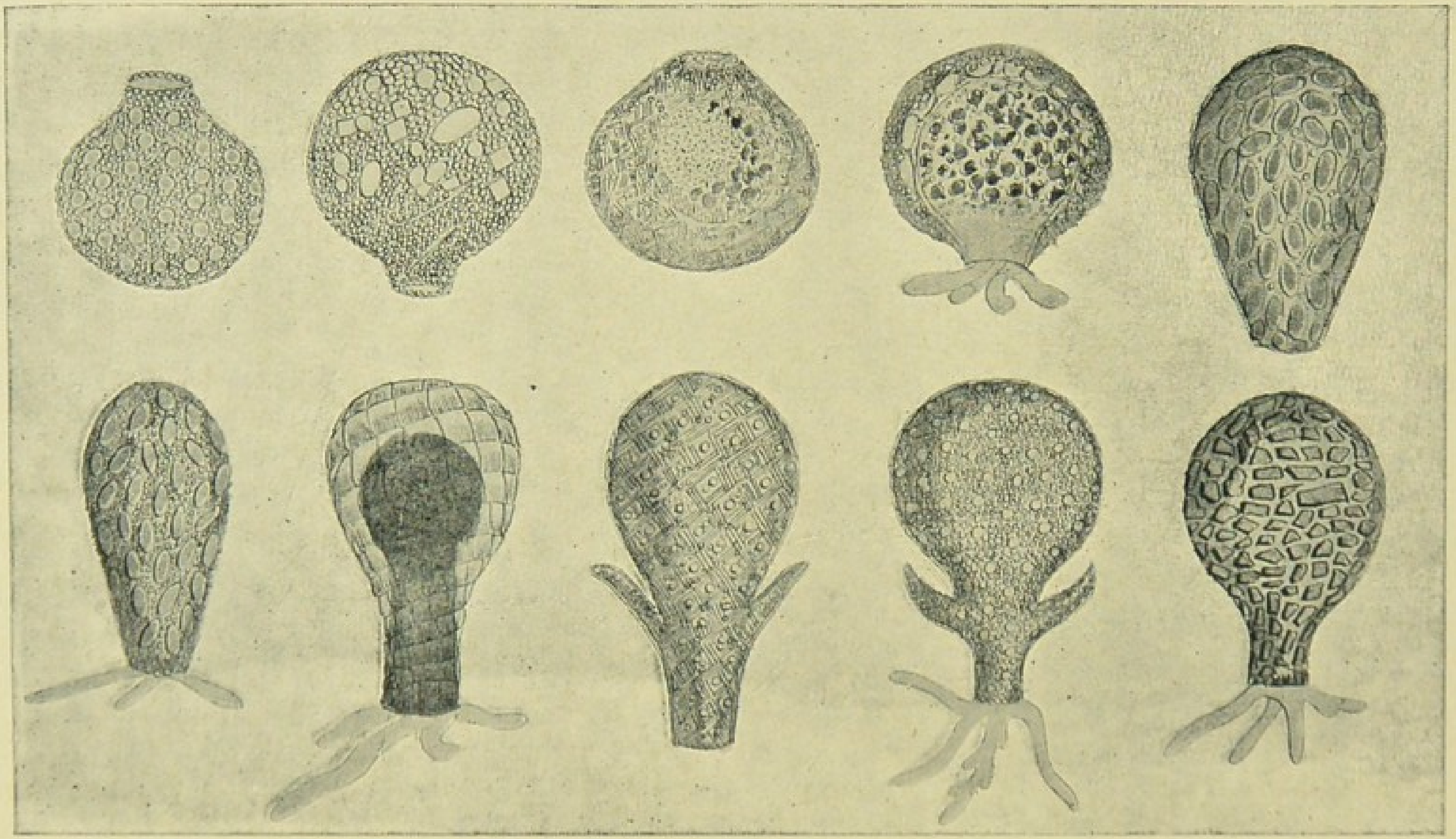

Fig. 41.—Nebela, Fresh-water Rhizopods (after Leidy). All are below the $\frac{1}{200}$th of an inch in diameter.

In the next illustration all the shells, with the exception of the last, are for the most part composed of animal matter belonging to the creatures themselves, and hardened into special shapes, some of which have ornaments in the way of plates arranged at fairly regular intervals. These shells, therefore, belong to the kind known as *intrinsic*. One or two, especially the last, partake of both characters. No. 7, in fig. 41, is a most remarkable specimen, made up of square plates. Its name, although somewhat large, is one which any of us might interpret, viz., Quadrula symmetrica.

All the shells of this illustration belong to the Nebela (Gk. *nebel*, a bottle) genus. Under the microscope they occasion as much interest as the Difflugia, and are always intensely fascinating, possibly owing to their extreme minuteness. All of them are below the two-hundredth of an inch in diameter!

To the Nebela belong some of the most beautiful rhizopods known to microscopists. They too are founded in marshy ground along with the sphagnum. Sometimes the moist vegetation swarms with specimens in full activity; at other times, in the same locality, under apparently similar conditions as regards temperature, light, etc., not a single creature can be found.

The arrangement of the shells of these mere specks in creation is of a most extraordinary character. In some we find circular or oval discs, discs that have no relationship in size with that of the shell, large shells having small discs and small shells having large discs. In some the shells are made up entirely of circular, in others of oval discs, while in others they are mixed, and, what is more astonishing, in some the larger discs are scattered, not indiscriminately, but with due regard to order, and even to decorative arrangement. The regularity in the intervening spaces approaches almost to the suggestion of a power of counting on the part of the microscopic particle of jelly-matter that we call the creature!

Several of these tiny organisms seem to object to either the round or oval patterns for their shells, and prefer rectangular plates! While others compromise matters by introducing a few oval shapes, and by a genius unfathomable by us, they construct a shell which bears a close resemblance to a tesselated pavement. The feelers or pseudopodia the creature puts out extend to the length of the three-hundredth part of an inch!! and are about the three-thousandth of an inch in thickness.

In fig. 42 we see the transparent shells of four other rhizopods, from three of which the jelly-specks are protruding, while in the one remaining the creature is undergoing a change and is drawn up into the shape of a sphere

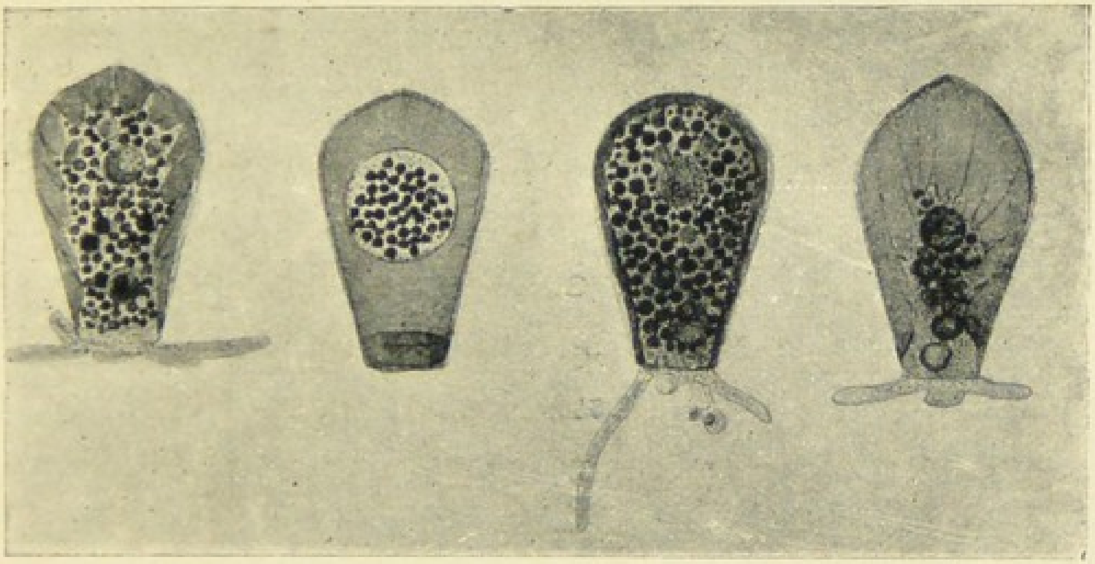

Fig. 42.—Hyalosphenia papilio (after Leidy). Ranging from $\frac{1}{250}$th of an inch to the $\frac{1}{450}$th of an inch.

These four forms are known as Hyalosphenia papilio (Gr. *hualos*, crystal; *sphen*, a wedge). We shall have no trouble with the second part of its name, if we know anything of butterflies. These creatures range in width from the four hundred and fiftieth of an inch up to the two hundred and fiftieth, and are amongst the greatest of swamp water wonders. They are always tinted yellow, and from their excessive beauty and their delicate transparency, their bright colours and lovely forms, as they move among the leaves of the sphagnum, desmids, and diatoms, they have suggested the idea of butterflies hovering among flowers, hence the name *papilio*. An observer of great experience, who has seen thousands of specimens from different localities, in mountainous regions, and nearly at the sea level, states that they undergo but little change—that a remarkable uniformity is maintained in their size, shape, and constitution, that he has never seen a shell positively colourless, and not one in which the sarcode was devoid of corpuscles coloured with the green colouring matter of plants and lower forms of animal life—known as chlorophyll. The life-history of this creature is not known. The Hyalosphenia papilio, like the previously described fresh-water rhizopods, is always found in marshy water with bog moss or sphagnum, but rarely occurs in ordinary pond water.

No adherent or extraneous bodies of any kind have ever been noticed on the shells. In this respect it greatly differs from the generality of Difflugia and Nebela specimens. The feelers, as in the case of the Nebela, extend to the three-hundredth of an inch, and attain to a thickness of three-thousandth of an inch!! It was owing to the discovery and subsequent

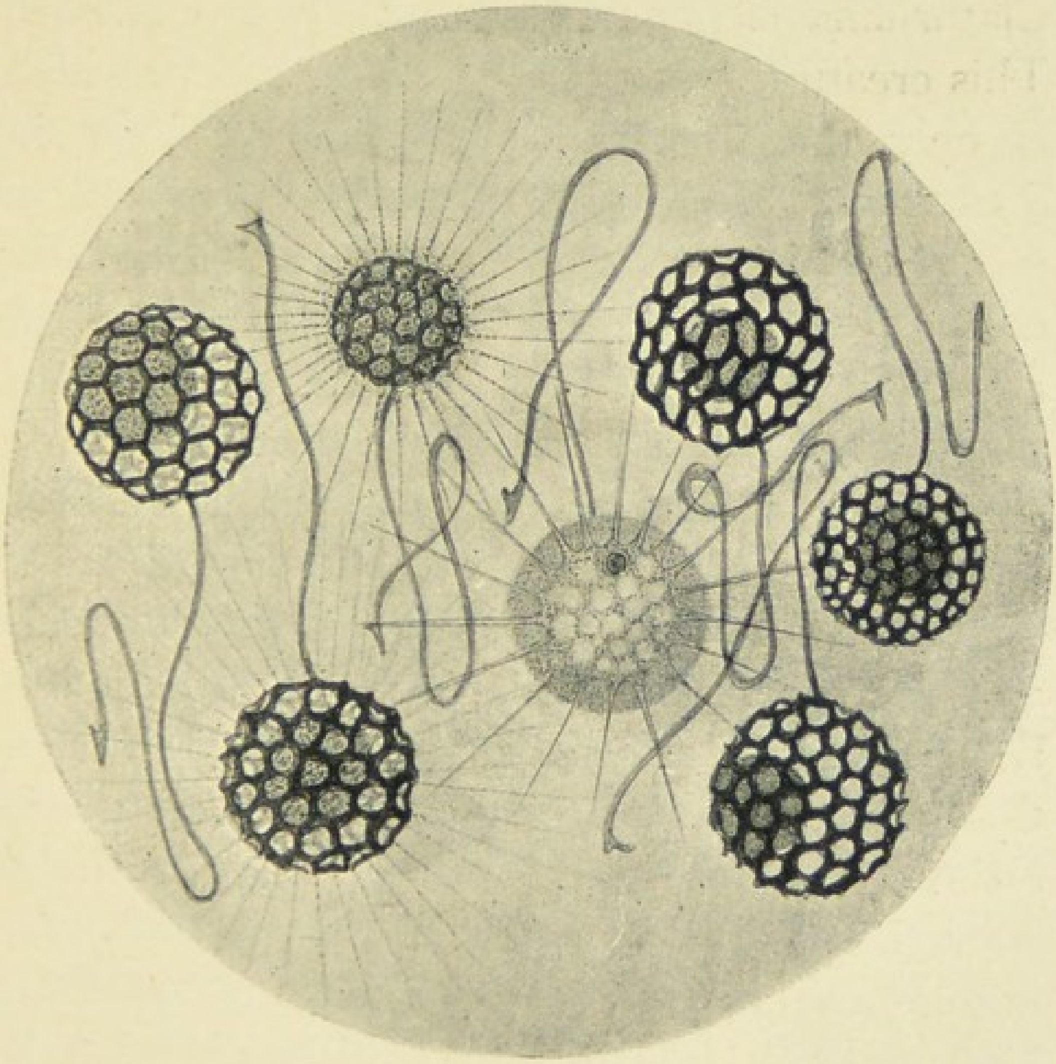

Fig. 43.—Clathrulina elegans, Fresh-water Rhizopods (after Leidy). Diameter $\frac{1}{1000}$th of an inch.

re-discovery of this creature that Dr. Leidy was impelled to pursue his investigations in this branch of life, and which led to his writing the standard American work on Fresh-water Rhizopods. Surely such splendid illustrations of life on a very minute scale deserve to be ranked as hidden beauties of Nature.

But what shall we say of figure 43, the famous Clathrulina elegans? (Lat. *clathrus*, a lattice). This creature possesses a latticed sphere which is only the thousandth part of an inch in diameter!! The sphere, too, is composed of flint!! This wonder of wonders was first discovered and described by the Russian naturalist, Cienkowski. He found it on the water plant nitella, in a pond at St. Petersburg. It has a long delicate stem, by which it attaches itself to plants. It can send its fine lines of sarcode out through the openings of the capsule and draw in its nourishment. Clathrulina has been found in other countries besides Russia. Germany, Ireland, England, and America also claim it. Doubtless it is to be met with all over the world, but owing to its extreme minuteness it evades detection unless under high powers. Like other rhizopods already noticed, it thrives in swamps, and evidently likes the neighbourhood of decayed vegetation. At first sight we think we have found an exceedingly small actinophrys, so close is its resemblance to that radiating jelly-mass, but on closer examination we find it is attached by an extremely fine stalk, and that it possesses an ornamentally perforated sphere. In one respect it approaches the actinophrys, but because of its beautiful flinty sphere it bears a close resemblance to the Polycystinæ, noticed under the head of Radiolaria. Cienkowski, who studied and described these creatures in 1867, tells us that the Clathrulina 'multiplies by division,' if we may use another Irishism. He states that the actinophrys-like body in the perforated flint sphere becomes contracted and divides itself into two parts. These separated parts, still in the sphere, withdraw their feelers, and appear as two tiny globes. They are so small that they pass out through the openings in the flinty sphere and assume the appearance of the previously-named sun animalcule, throwing out rays in all directions. Next, they develop a stem of attachment similar to that of the parent, and afterwards the ornamentally perforated flinty ball, or 'latticed capsule,' enveloping the head. Let us bear in mind that this 'latticed capsule,' which contains all the animal proper, is but the thousandth part of an inch across. A thousand to make an inch! a million to make a square inch!! a thousand millions to make a cubic inch!!!

Whatever adjectives we may have employed in extolling the perfections of other rhizopods

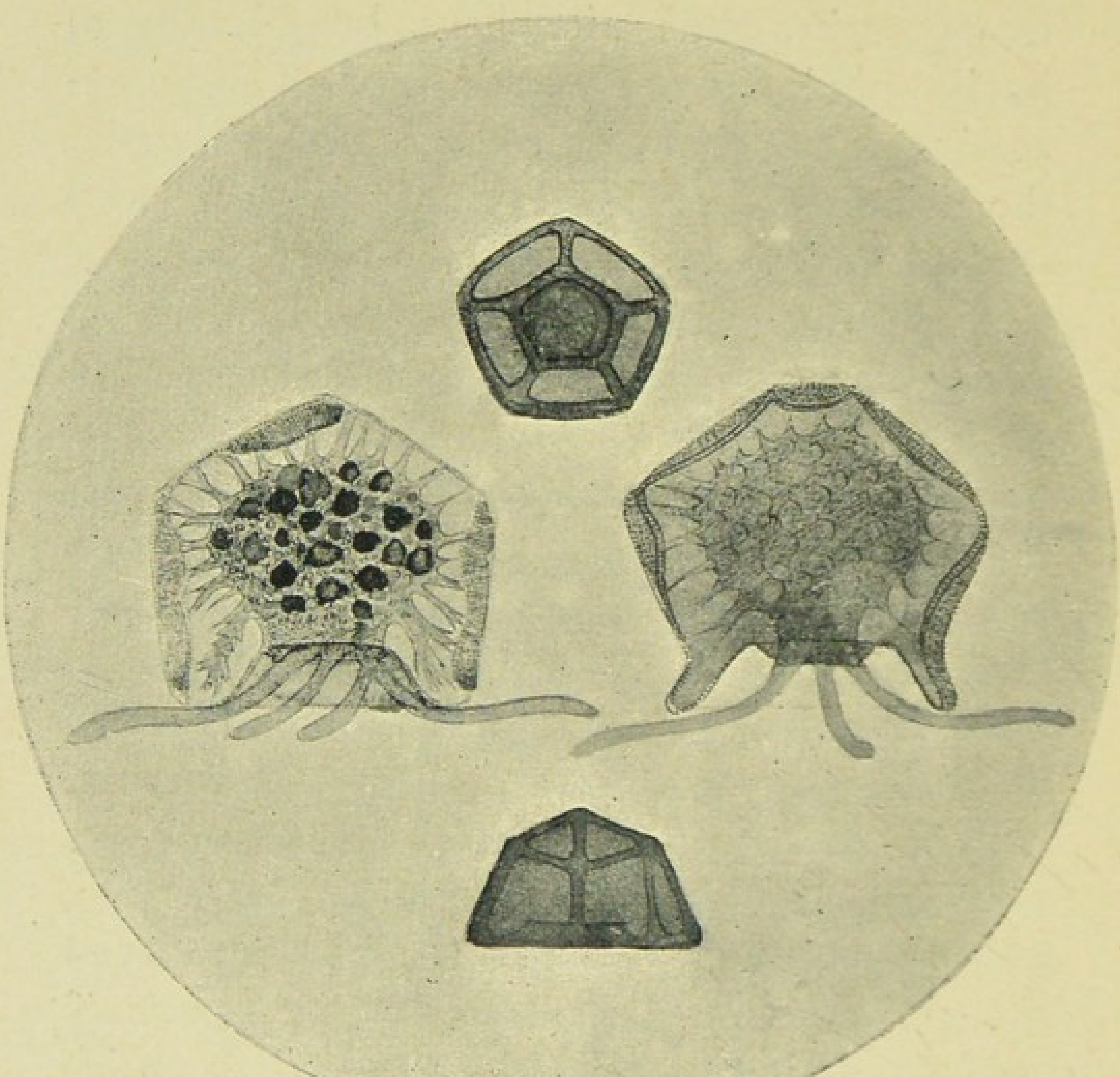

Fig. 44.—Arcella, Fresh-water Rhizopods (after Leidy). From $\frac{1}{120}$th of an inch to $\frac{1}{320}$th of an inch.

will now apply with equal if not with greater emphasis to the Clathrulina elegans.

The rhizopods shown in fig. 44 are known as arcella (Lat. *arca*, an ark; arcella being the diminutive form). They were first described by Ehrenberg in 1830. The shell is part of the creature's own integument, and is therefore *intrinsic*. Its width varies from the three-hundredth to the one hundred and twenty-fifth of an inch. The shell seen under very high powers shows a minutely hexagonal structure, and is translucent. These hexagons are said to be the twelve-thousandth of an inch across! Not only this, but they are hollow, like so many saucers.

The arcella is found in standing water. It feeds on algæ and other vegetable matter, and is frequently found on the surfaces of submerged plants.

When it grows too large for its shell, it comes out and secretes material for a new covering. Sometimes the old shell and the new one are found together; the former is generally much darker than the new one. Until the new home is quite complete the creature lives partly in one and partly in the other. When, however, the old home is finally forsaken, it splits.

Small cell-like bodies have been observed by Bütschli to escape from the mouth of the shell, and to assume the movements and appearance of the amœba. But he was not able to ascertain if they were the young brood of the arcella. Our information respecting this creature is far from complete, so that another opportunity awaits the microscopist.

Fig. 45 represents another class of Rhizopods known as Cyphoderia (Gk. *kuphos*, curved; *deros*, the neck). These creatures have a retort-shaped shell, which is transparent and generally coloured, and which is intrinsic. Under high magnification this creature is an object of great beauty. Its diameter is about the three hundred and sixtieth of an inch!

In 1840, Ehrenberg wrote an elaborate account of these rhizopods. They are found in the surface matter of springs, ponds, lakes, and ditches, not only in America, but in various parts of Europe, notably in the mud brooks of the Jura and Vosges Mountains. The hexagonal structure of the shell is very apparent. The feelers are numerous, and are susceptible of a great variety of movement and change of form.

To appreciate these, and in fact every phase of microscopic life, we should see them endowed with life in a glass tank under high powers.

Illustrations cannot be expected to give any more than a faint idea of their true loveliness.

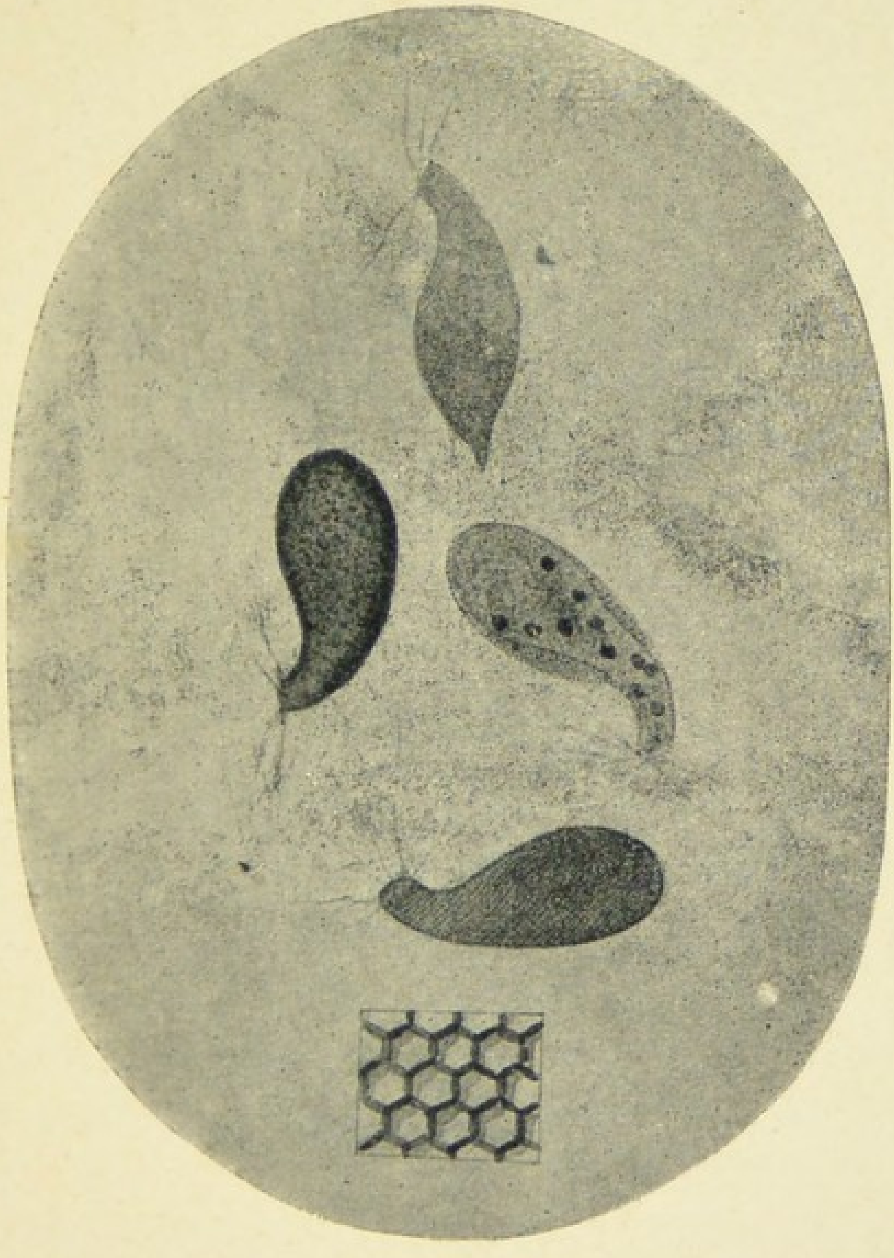

Fig. 45.—Cyphoderia, Fresh-water Rhizopods (after Leidy), $\frac{1}{300}$th of an inch in diameter.

For the purpose we have in view, we have described a sufficient number of the fresh-water rhizopods. It is a never-ending panorama of minute life, well worthy of our most careful examination.

> '. . . Where the pool
> Stands mantled o'er with green, invisible,
> Among the floating verdure millions stray.'

CHAPTER XIII

CORALS

THERE is a world of hidden beauty both in a piece of coral and in the tiny creatures which secrete it from the surrounding waters. A small piece of white coral, about four inches long and scarcely two in width, is found to contain numbers of recesses beautifully arranged.

There is no definite shape that we can describe, yet all over it there is an unmistakable attractiveness that prompts us to place it among our treasures rather than to throw it away.

Such a piece has been photographed for me, and from the photograph a lantern slide has been made. I place this in the lantern and throw an illuminated picture of the coral upon a screen over twenty feet high and about the same width. The coral is now made to appear twenty feet long, yet its texture exhibits innumerable cavities that will bear the closest examination and still be perfect. Audiences imagine, until matters are explained, that they are looking at the photograph of a very large block of coral.

Fig. 46.—Coral Polyps.

Coral polyps in the past have helped forward the structure of islands and continents, and have been among the great elevating agencies continually at work in opposition to the wearing away or *degrading* influences. During man's time on this earth they have lived, and without cessation have secreted from the warm ocean

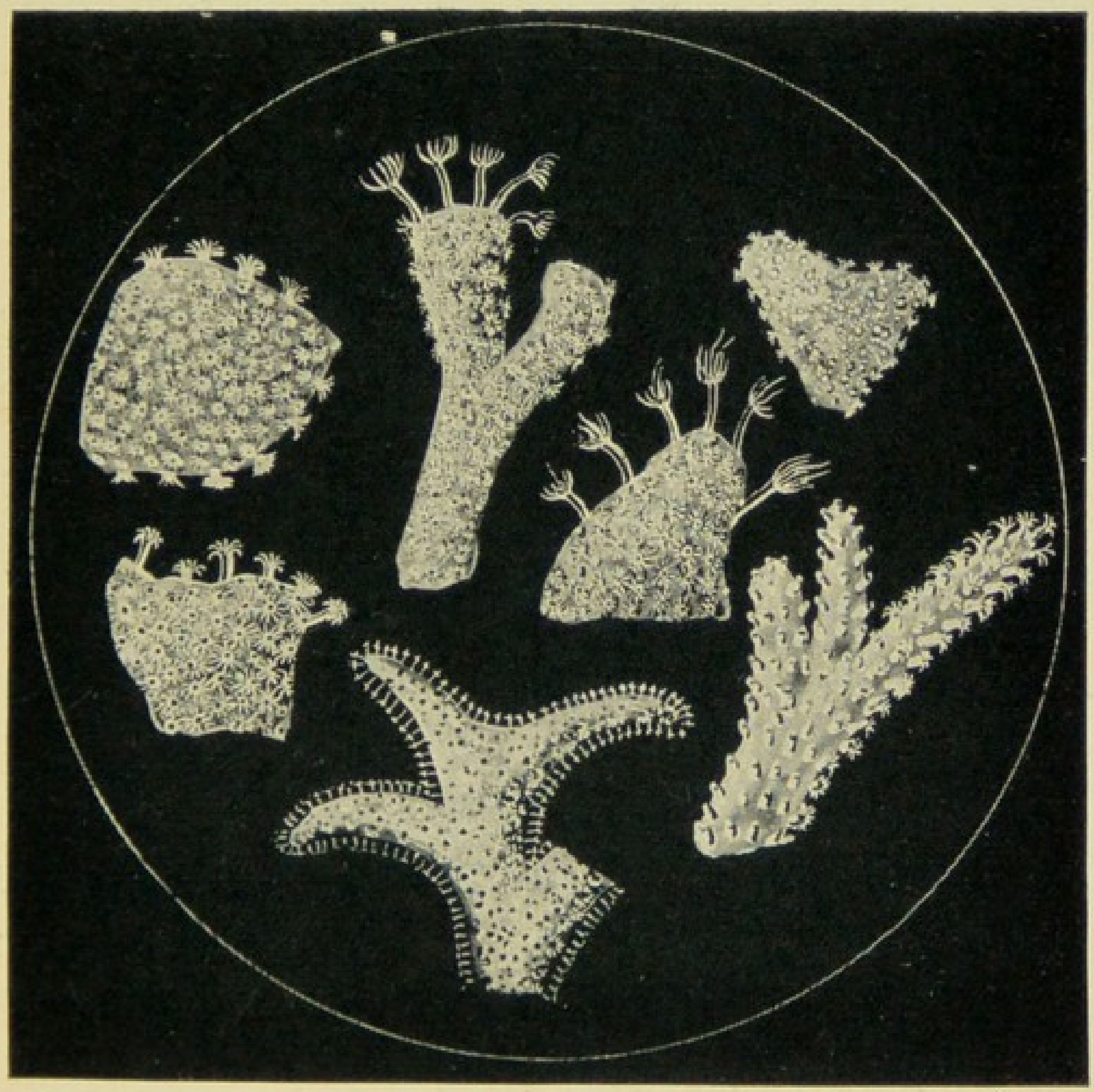

Fig. 47.—Corals with extended Polyps.

waters the carbonate of lime we call coral. And still their work goes on, and islands are being reared and continents are receiving additions owing to their incessant activity.

By studying Nature closely we shall soon perceive that the agents employed by the Creator in the construction of vast areas of the rocky formations of the world were and are for the most part exceedingly small in size, many, in fact, are microscopic organisms. Yet, that they have lived, and that for a definite and useful purpose, is evident to all who inquire into Nature's wonders. The more bulky animals have done nothing at all comparable with that which characterises the lives of coral polyps, sea and fresh-water rhizopods, the radiolarians and globigerina.

The reefs, miles in extent, enlarging the boundaries of land near which they are situated, are the outcome of coral polyp agency. Myriads of tiny creatures, beautiful in shape and colour, are hidden away under the surface of the ocean, and by means of a marvellous power of which we have no knowledge, food and carbonate of lime are drawn from the water. Many varieties of coral polyps have the additional power of being able to extract colouring matter, which gives an extra charm to coral specimens. The different shapes exhibited by coral are endless, showing that the polyps themselves must be as varied in structure, etc.

No complete classification of coral polyps has ever been made. Each exploration of coral reefs brings to light several forms that are new

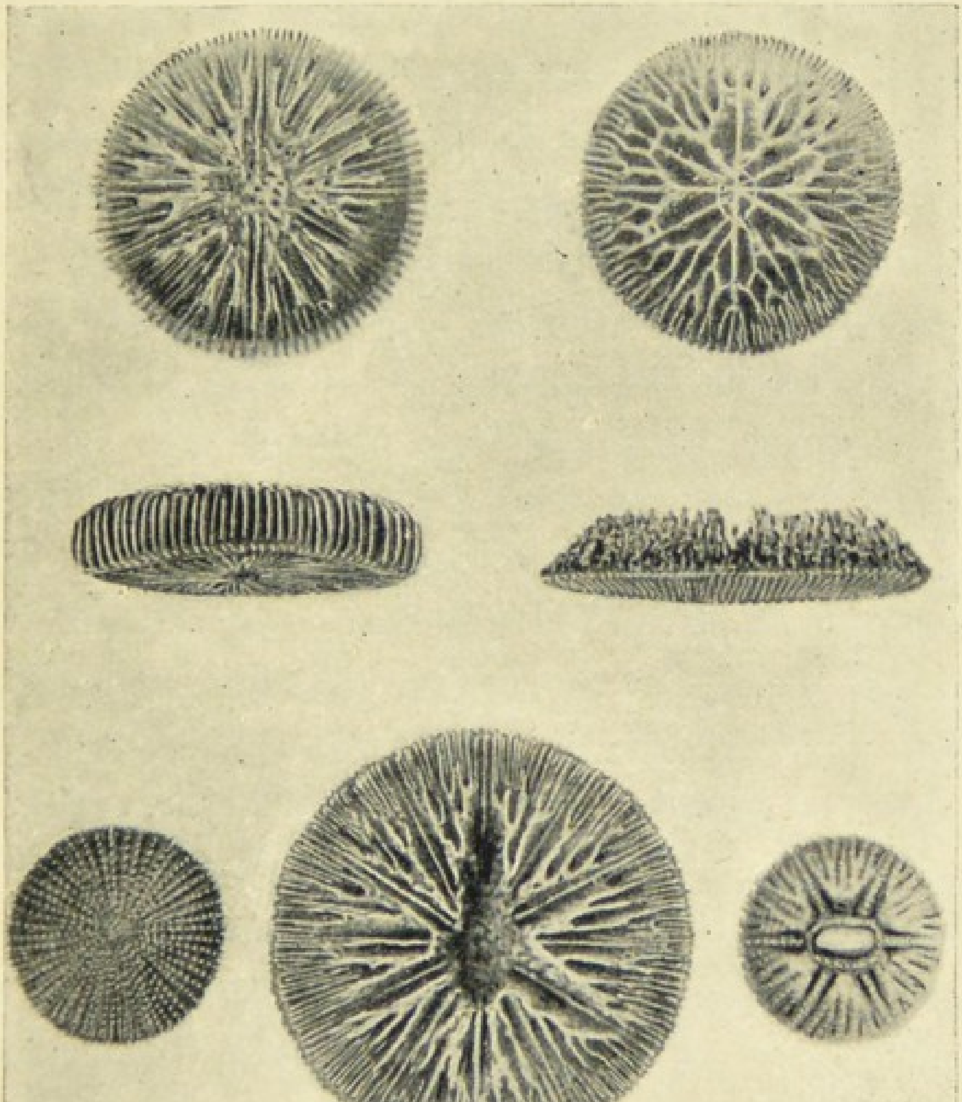

Fig. 48.—Madrepores.
(*South Kensington Museum.*)

to our national collections. Days of profitable study of corals alone might be made at the

Cromwell Road Museum, and even then the information gained would be incomplete. The great bulk of our population can know nothing of the pleasures to be derived from the study of these and other priceless treasures of the matchless collections of natural history objects in this museum. Were it otherwise, the buildings would always be thronged with visitors in pursuit of knowledge far more satisfying than anything provided at the low-class music-halls, now so much frequented.

Before dismissing the coral polyps, these hidden beauties of Nature, it would be well to survey a single reef, in order that we may in a measure realize the importance of their existence. The Great Barrier Reef, off the east coast of Australia, is 1,250 miles long, with an average breadth of 30 miles. It is an archipelago of coral islands and reefs with many openings, but only twenty-two of which are navigable. Nine only are regularly used for navigation. Numerous creatures of various kinds, such as trepangs, stone-fish, ox-rays, pearl oysters, etc., have their abode in proximity to the reef, so that the fishing grounds are a prolific source of profit to the Government of Queensland, the annual value of the exports being £100,000.

The reef protects the east coast of the continent from the wearing influence of the ocean, and acts as a sieve, in that it retains the silt brought down by the rivers. In time it is likely to add extensively to the area of Australia by its protecting and retaining effects. In fact, the reef is a 'harvest-field, rich from both a commercial and a scientific standpoint.' It only needs the exploration and development of its marvellous resources to bring great wealth to the Government and all connected with it. The sea between it and the continent is equally rich in animal supplies. This enclosed water varies in width from ten miles to one hundred and fifty, and cannot be less than 80,000 square miles in extent—the result of the life of miscroscopic organisms having lived their cycles of life.

There are various opinions as to the formation of coral reefs—Darwin's theory receiving the more general support. But whatever question may be raised as to the 'gradual sinking' theory, or the 'elevating' or other theories, there can be no question as to the beauty of the teeming life in the clear waters about the Australian Barrier Reef. We are acquainted with the madrepores and other corals only in the shape of dry skeletons, bereft of beautifully coloured feelers or discs, which in their natural element protrude from every one of the innumerable mouths or openings on the surface of the coral rock, and which give the sea pools the appearance of a marine flower garden.

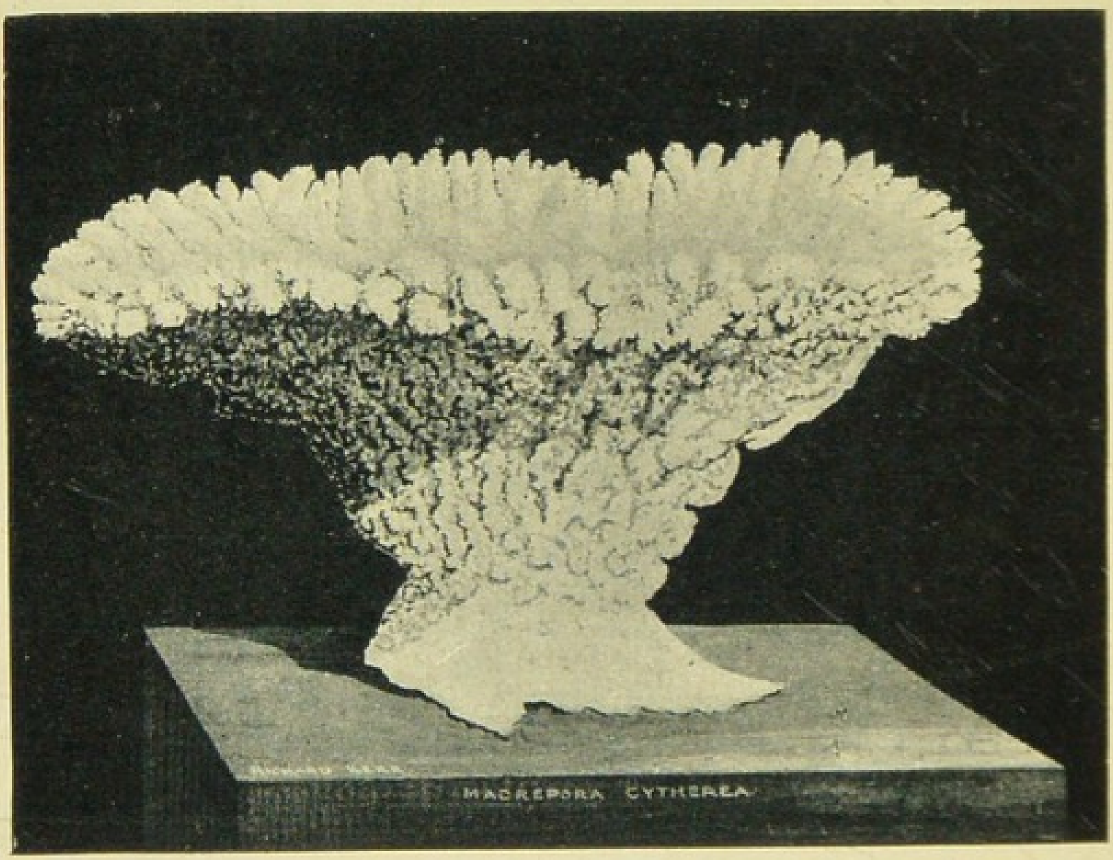

Fig. 49.—Madrepora cytherea.

The corals sent home from this remarkable reef by Mr. Saville Kent may be seen in the Cromwell Road collection, and on the adjoining walls are photo-mezzotypes of the seascapes along the direction of the reef. His famous book on this subject is the best monograph on corals ever produced.

We must note one or two more points in the history of corals. The evidence of the principal students of marine life tends to show that reef-building polyps cannot live below a depth of twenty-five fathoms, or one hundred and fifty feet.

Coral polyps are extremely sensitive to atmospheric action, so that 'no coral reef can grow above the level of the lowest tides, and therefore all subsequent additions of material must be due to accumulation of sediment transported by the action of the tides and prevailing winds.'

Owing to the action of the tides, portions of the reef are broken and pulverised, shells of molluscs are smashed into tiny fragments, tubes of serpulæ and stalks of sea-fans are worn down until the water is white with fine particles of carbonate of lime. Frequently the polyps are completely covered by this detritus, so that they cannot flourish.

A current that removes a great deal of the superfluous carbonate of lime, and that brings them a plentiful supply of food, promotes their health and the corresponding growth of the coral reef or block. It is an advantage to them if their reef be in a sloping position influenced by tides and currents. The author of *The Voyage of the Blake* says: 'It is not an uncommon thing, after a blow, to come upon this water, discoloured by the fine calcareous silt, to a distance of six to ten miles from the outer reef.' He is here speaking of the coral formations of the Tortugas. We have no definite information as to the rate at which corals grow; but naturalists of the future will be able to make fairly approximate calculations in this direction, owing to the care which Mr. Saville Kent has taken in his measurements of characteristic blocks of coral, the locality of which he has carefully mapped down. It is the opinion of Prof. A. Agassiz, in describing the Florida reef, that it would take from a thousand to twelve hundred years for corals of this locality to rise from the seven-fathom line to the surface. 'This,' he says, 'would give no clue whatever to the actual age of the reef, because it is difficult to determine how far the width of any coral reef is due to the growth of coral. But supposing the reef to have an average width of half a mile, and its lateral growth to be say four or five times more rapid than its vertical increase, we should get at least 20,000 years as the age of the outer reef.'

A question that at once presents itself is :— How then about the time when the great solid rocks were formed that are entirely composed of masses of corals of still more remote ages? We become bewildered with the thought, we have no standard of our own time by which we can approximate a calculation, and we are constrained to believe that our lifetime, so far as this world is concerned, is extremely brief.

The coral polyps cannot thrive unless the temperature of the water all the year round be over 68° Fahr. In England we frequently see evidences of coral growths belonging to the remote past, as at Newton Abbot and other parts of Devon, but the mean annual temperature of our surrounding waters is much less than 68°, so that our climate must be quite different from that when these corals were tenanted with beautiful polyps.

We can hardly fancy that parts of England were reared by or owe their stability to coral growths. An inquiry into the origin of many islands and even portions of continents would convince us that the coral polyps of the past have left behind them veritable monuments that are hundreds of miles in extent. Not a few geologists believe that the Dolomite Mountains are the direct result of coral agency!

Their chemical composition—magnesia and carbonate of lime—supports this belief.

In speaking of the coral creatures we must discard the term 'insect' in favour of 'polyp.' An insect is a creature that in one stage of its life must have six jointed legs, a body almost cut into two parts, hence its name, a complicated nervous system, besides circulatory and visceral systems. The coral polyp can lay claim to none of these possessions. It resembles the sea-anemones of our own Channel off the coast of Devonshire, with this advantage, that it has power to secrete a coral skeleton—a power, however, that is quite involuntary. This property of secreting a hard calcareous skeleton is not a building process, any more than our skeletons are voluntarily built by us. Different kinds of polyps secrete different kinds and patterns of corals. The polyps which secrete fungiform coral could not secrete the branched madrepore, neither can the madrepore polyp produce organ-pipe coral. The radiate structure of ordinary corals is but the expression of the internally radiate structure of the polyp. When alive, the top and usually the sides of the coral are concealed by the outer skin of the polyp, including above the disc and tentacles, and into the depression or calicle at the top. The polyps are able to elevate their crowns above their coral discs, and to spread out their tentacles or feelers, and to retreat again to the insterstices or cells, as the case may be.

The creature sends out a bud similar to the hydra of our ponds, a mouth appears in the bud, feelers next appear, the bud then enlarges to the size of its parent.

In the case of hydra, the bud at this stage severs its connection and becomes a free and independent creature. Not so with the coral bud. It seems to realize that 'union is strength,' for it remains, and similar buds are formed, so that as the budding process continues, a compound group is the result; and still the buds are added to the living colony until hundreds of thousands are produced from a single polyp.

The living mass may now be several feet in extent. It is evident that in all such compound groups a living connection between all the members of the same colony must exist which is of the most intimate character.

The respective polyps of the colony have separate mouths and tentacles and digestive cavities, but beyond this there is no separate estate. 'They are one by intervening tissues, and there is a free circulation of fluids through innumerable pores. The colony is like a living sheet of animal matter, fed and nourished by numerous mouths and as many stomachs.' If any individual refuses to search for food it dies, and the colony simply loses one of its many members. But searching for food cannot be a very laborious undertaking, inasmuch as it is brought to their very mouths by tidal action and currents perpetually passing along, laden not only with food but with carbonate of lime, and where requisite various kinds of colouring matter for their beautiful skeletons.

'All
Life's needful functions, food, exertion, rest,
By nice economy of Providence
Were overruled to carry on the process
Which out of water brought forth solid rock.'

CHAPTER XIV

THE COMATULA, OR ROSY FEATHER STAR

WHEN spending a holiday at the seaside you will have the opportunity of finding numbers of the lovely objects which live in the water near the shore: tiny starfishes, sufficiently small to crawl about on the nail of your little finger; very small sea-urchins, much smaller than an ordinary-sized marble; little sea-anemones, and small creatures that you may mistake for starfishes, but which have eight arms, and may be called sea-spiders. By careful searching on some coasts, you may be rewarded by finding the little rosy feather star. If you have a microscope, there will be hosts of things awaiting your attention, such as Bowerbankia, a most charming creature that receives its name from the fact that the late Dr. Bowerbank was the first to draw special attention to it. Then there are various kinds of sertularians that are frequently passed over as seaweeds, but which are colonies of intensely attractive forms of life, also the spirorbis, whose tiny white shells are attached in multitudes to the seaweeds proper.

These are but a few of the treasures that may be studied with interest and advantage. It will be advisable to take them home in a good supply of sea water, to allow them a quiet time, and to avoid all shaking. These small things of Nature are very particular, and will not divulge much of their beauty or give much information to careless or trivial people.

Suppose we take one of these objects for the present, and follow out some of its characteristic features. We select the rosy feather star, because it is a representative of the ancient lily encrinites, a tribe of lovely creatures that in the remote past held an important place on the floors of oceans. The central disc of this creature is about the size of a pea. It has ten arms, which it can move at will with a grace that surpasses any exercise movement ever performed by an athlete. In some specimens, these arms are about an inch and a half long, and are united in pairs, each pair branching from a short common stalk. They are made up of a large number of joints covered with transparent crystalline flesh. Its ten arms have thirty or forty pinnules down each side, so that the arms very much resemble living feathers, hence its name.

The thin transparent flesh which covers every part of the creature is covered with innumerable cilia so closely arranged that the whole appears like living rose-coloured velvet, in which the pile is in constant vibration. A groove runs down each armlet, meeting a larger central groove which extends from the tip of the arm to the creature's mouth, situated in the centre at the point to which the ten arms converge.

The vibration of the rose-coloured 'pile causes a current of water to flow along the tiny grooves into the larger ones, and from thence into the mouth. In this way food and oxygen are conveyed for its nutriment.

On the underneath side of the disc, in place of arms, there are about twenty jointed, curved hooks, by means of which the feather star anchors itself to the rock it selects as a resting-place.

The creature looks very much like a few sprays of pink seaweed. This may be so ordered for its protection. In its young condition of life it is attached to a stalk, and then looks like a flower on a very thin stem. Particular attention should be paid to this fact, because it is mainly in this respect that it bears close resemblance to its mighty predecessors which we must notice further on.

Now the extreme delicacy of texture and colouring in the feather star would of themselves make it an object of attraction, but to these characteristics it adds another—namely that it never holds its arms or pinnules in any but a graceful position. The curves are always perfect. Sometimes the arms appear like ten crescents arranged in the form of a living crown. Then they gently curve outwards at the tips, and each assumes a shape like the letter S, all the arms observing a law of perfect symmetry. The next position is that of a spiral, and ere long each arm adopts a form like a note of interrogation. Crowns of different patterns are imitated, and all accomplished with a grace that is indescribable.

It will be imagined, therefore, that the rosy feather star is one of Nature's most beautiful sights, well worth seeking out, although generally most carefully hidden in out-of-the-way places. But there is one more movement which seems to surpass all others. Suppose the creature wishes to raise itself in the water. Instantly five alternate arms of the ten give a downward sweep describing rapid S curves, whilst the other five are incurved spirally. These then give a similar downward sweep, whilst the first five assume the incurved position, and so with alternate strokes the creature raises itself in the water and hovers—then it slowly sinks with all its arms upraised and meeting at the tips.

This attractive creature belongs to the Echinodermata, a sub-kingdom of animals which includes starfishes, sea-cucumbers, etc. Its proper place is the Crinoids, the fossil representatives being called 'stone lilies.' These fossil forms are found in such large quantities as to cause geologists to name the rocks after them, *e.g.* 'encrinite limestone.' The living creatures had stalks, which enabled them to fix themselves to the sea bottom, while the animal proper resembled a starfish. The stalks and arms of the creatures must have been made up of five-sided or rounded segments, for on breaking up the encrinite limestone the segments fall out in hundreds. These are known in some districts as 'St. Cuthbert's beads.' In the more durable kinds of this limestone, the fossil forms may be seen *in situ* on any wet day wherever the footpaths consist of this rock. (See *A*, fig. 38.)

It was thought that the whole family of

encrinites had died out long years ago, but Professor Sars, of Norway, succeeded in bringing up from the floor of the North Sea a living representative, which greatly astonished our naturalists, and which he called Pentacrinus Wyville Thomsonii, after the famous naturalist of the Challenger Expedition.

Thus the study of the little rosy feather star leads us to look back to geological times, and to see its connection with mighty colonies of larger creatures which have contributed in no small degree to the formation of the rocks of the globe. Such studies, while bringing out the hidden beauties of Nature, must fill our minds with wonder and reverence.

CHAPTER XV

THE BUILDING ROTIFER

It is said that if we take the largest of land animals, the elephant, and the smallest of living creatures ever viewed with a powerful microscope, the creature which occupies the midway position between the two extremes is the house-fly. Imagine, if you can, creatures as much smaller than the house-fly as the house-fly is smaller than the elephant. It may be possible for the mind to picture such creatures, but what mind can understand the complex laws which regulate and control their existence? We frequently express the limit of our seeing powers when we say this or that object is as small as the dust in the sunbeam, but there are exquisite specimens of the hidden beauties of Nature much smaller than the dust.

It would sound like the language of romantic exaggeration if we were to say that a beautiful house built with bricks exists, which is so small that it would readily drop through the eye of the smallest needle used in sewing. Yet such is the fact. Several of such houses, if fastened together, would pass through that minute opening.

The Building Rotifer (Melicerta ringens) is found in most of our English ponds. It makes its home on plants, such as Valisneria spiralis, duckweed, or the American weed, anacharis, etc.

In an audience engaged in examining microscopic beauties, if a vote were taken as to which was the favourite object, most probably the building rotifer would obtain the highest number of votes. The exhibitor holds up a small glass tank in which he has placed a few drops of pond water and a portion of the above-named plants, and he says, pointing with a needle, 'Do you see a tiny dark-brown speck on the edge of that leaf or stalk?' as the case may be. The person addressed examines the water, and after looking closely, exclaims,—

'Yes; I see the merest speck.'

'Quite right,' responds the microscopist; 'only that is not "building rotifer," it is "rotifer's building."'

To see the builder we must place the tank under the magnifier and throw a light through the water, and remain perfectly quiet for a minute or two, as building rotifer objects to much vibration.

Then a wonderful sight appears. Rotifer

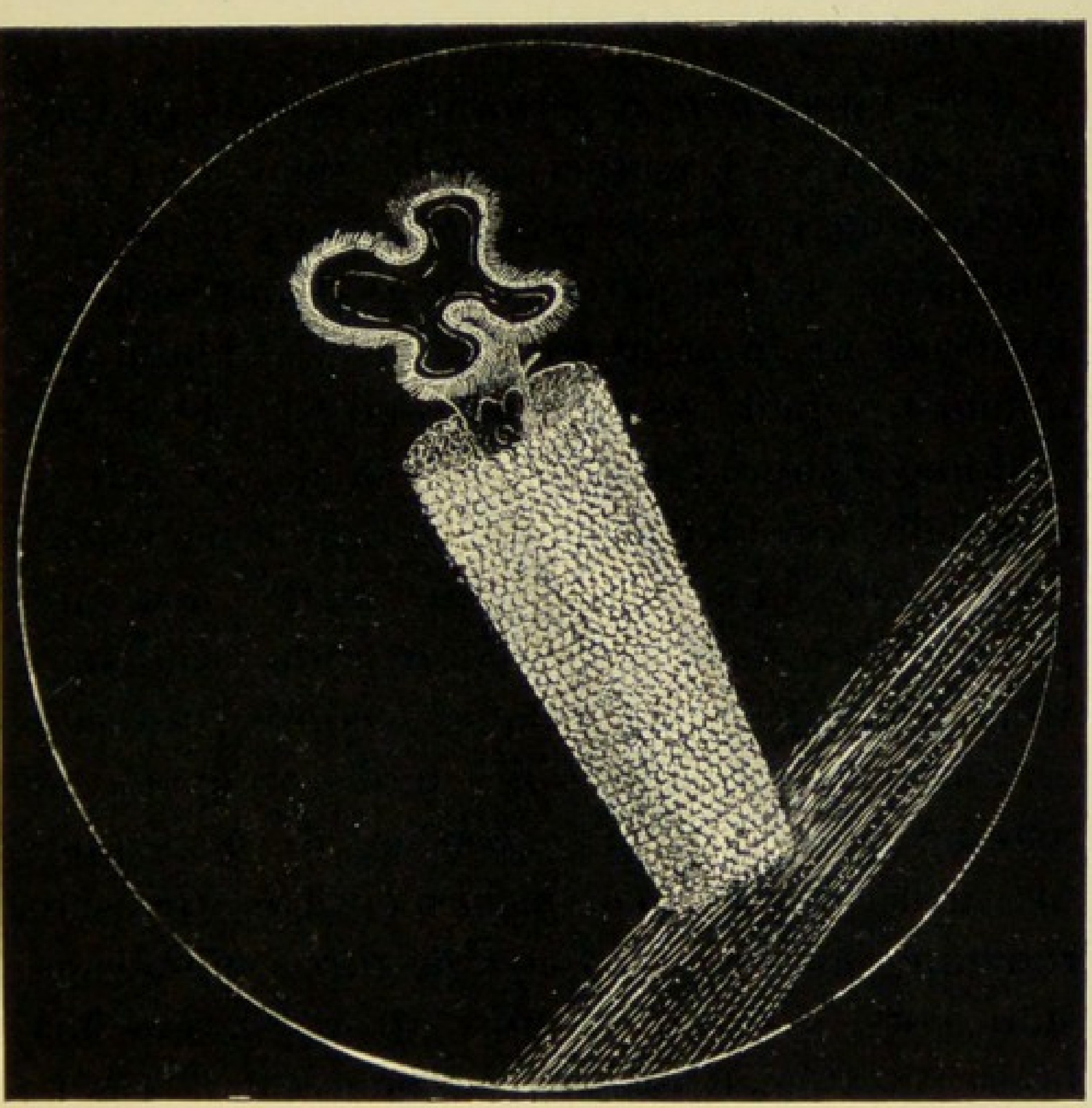

Fig. 50.—Building Rotifer (Melicerta ringens). $\frac{1}{30}$th of an inch in length.

unfolds a disc fringed with cilia or tiny lashes. The motion produced by these lashes has a peculiar effect on our eyesight. We have a difficulty in getting away from the impression that the whole disc is rotating, and that a set of cogs is on the wheel margin. Clever men, however, tell us that the illusion is due to the cilia lashing the water with regularity in one direction.

This rapid motion performs a wonderful duty for rotifer. Together with the creature's swallowing power, it produces a tiny vortex or whirlpool, so that particles of food and building material are brought within reach. These are taken to their respective centres. That for building material is collected in a cup, and is gradually moulded into bricks, which by a dexterous and rapid movement of the disc are placed in position on the edge of the wall, and, wonderful to say, remain securely fastened although in water. The time occupied in making a brick varies according to the supply of earthy matter held in suspense in the surrounding medium. Generally three minutes is sufficient. As the creature grows larger his house must increase in size, hence it is cigar-shaped, the narrow end being the base.

An experiment often tried, is to get these tiny objects to make blue or red bricks. To accomplish this end we place a little indigo in the water. In the course of an hour or two we find that the water is clear and that a few tiers of blue bricks have been added to the structure. We next immerse a tiny supply of carmine, allow an interval of time as before, when the water will again appear clear, and rows of carmine bricks will be found in position. It is thus possible to have a tri-coloured house; the brown bricks at the base are made of clay found in the pond water, the blue and the red as above described. To see this creature at its best it is necessary to procure those rotifers whose houses are in the early stages of construction, as they are not so sensitive to disturbances as those whose works are more advanced. They work night and day to establish their homes.

If twenty-five, or even thirty, microscopes be used in a hall, and their owners exhibiting to a large number of people various forms of marine and pond life, by far the greater number of people will be assembled to see the 'brickmaker' at work. Its house is about one-thirtieth of an inch long and the eightieth of an inch wide. It is most difficult to obtain an accurate drawing of the 'brickmaker' or his house, nor up to the present does the problem appear to be solved by photo-micrography, or photographing them through the microscope.

Several forms of low life are a great puzzle to naturalists, owing to the remarkable power which they possess of resuscitation after they have been dried to a powder and allowed to remain apparently dead for some years. Building rotifer is said to be one of these extraordinary creatures. Ehrenberg, the celebrated German naturalist, conclusively proved this by actual experiment.

Rotifers have rudimentary nerve centres, muscular fibres, and a system of vessels for the due circulation of fluids through their bodies. Their digestive apparatus is more perfect than that of many forms of life that are more bulky. Instead of dividing and subdividing, in order to multiply their species, they have power to produce eggs, which are hatched in the cigar-shaped home. The little creatures swim about freely, but only for a time. In this respect they resemble the young of the sponge, not in appearance, but in their freedom from parental restraint. It was the general opinion that rotifer was endowed with sight only in the days of its youth, that when it settled down finally and began to construct its house its eyes disappeared. A careful examination does not bear out this erroneous supposition. The position of the eyes is changed ; but occasionally, with favourable conditions of illumination and position, the tiny brilliant specks can be seen in the adult forms. Besides its behaviour in selecting materials for brick-making, its quickness in rejecting substances unfit for food or for manufacture, its knowledge as to where the succeeding bricks in each row are to be laid, all point to the fact that the creature has eyes, and good ones into the bargain. Ever so many duties are carried on at the same time by friend rotifer. It collects clay held in suspense in the surrounding pond water, it collects food, it separates building material from food, and rejects worthless substances, it grinds its food, moulds the brick, and places it in position. To make the brick impervious to the dissolving powers of the water, it must be coated or mixed with some mysterious substance provided by the creature itself. And so durable does the cement make the fragment, that it lasts long after its intelligent tenant has passed away. The word 'intelligent' may be objected to, but I cannot look at this creature without feeling that it is endowed with intelligence of a high order, notwithstanding its extreme minuteness.

The movements of the cilia bordering the disc are quite under the control of the creature, for they show all the characters of voluntary motion; undoubtedly they are regulated by the will of the animal, for they can be made to move with 'extreme rapidity, put into gentle and tranquil action, or stopped in an instant.' Again, at times one portion of the cilia is busy while the rest is inactive. Presently the whole row, or rows, vibrate so rapidly, that we lose view of them, and only see the effects produced in the water.

The study of Melicerta ringens alone is enough to draw out our admiration of the Creator's works, and to teach us to be humble.

Long ago, Dr. Chalmers said, 'It is a most Christian exercise to extract a sentiment of piety from the works and appearances of Nature.' Surely such studies as those of rotifer are among the 'pure pleasures' of life.

CHAPTER XVI

THE BEAUTIFUL FLOSCULE AND VOLVOX GLOBATOR

Some of the microscopic creatures of our ponds possess transparent houses, which we say are hyaline or glassy, for the want of a more appropriate adjective. The name Floscularia ornata would, by its sound, lead us to expect an exceptionally lovely object, and so it is. It is exceedingly small, quite below the power of our unassisted sight, and therefore, if we wish to see its beauty, we must use fairly high powers attached to our microscopes, and we must exercise patience. We see a tiny transparent mass, then it moves forward, extends, and at the same instant it unfolds a bundle of extremely fine feelers. It immediately assumes the shape of a lovely vase with five points with five festooning curves between them. The points seem like small electric lamps, and from these proceed in all directions the cilia,[1] like beams of light,

[1] See the frontispiece.

thus completing the idea of electrical resemblance.

The five-pointed vase surmounts a graceful stalk. We alter the light of our microscope lamp, and we look more closely, and after some time we discover the hyaline house. We vibrate the water, and instantly cilia, lamps, vase, and stem are withdrawn inside the glass house. But this withdrawal is only for a moment. The performance is repeated, and the cilia again shoot out and bring in invisible food, which is guided into the receptacle.

These creatures are attached to water weeds, and are great favourites with all students of pond-water life.

The crown animalcule and hosts of other marvels await our inspection in ponds and streams. All those tiny creatures who possess a glass house, as we erroneously call it, are sure to create profound interest. They are ornamented, and perform such wonderful feats, that we look at them for hours in amazement.

That they have their duties in life there can be no doubt.

Whatever else we may learn from them, they certainly teach us the lesson of industry.

Whenever we take home a supply of water and plants from any fresh-water pond, it would be worth the trouble to carefully examine the *debris*. We are almost certain to meet with floscule. All the members of this attractive class of creatures possess the gelatinous tubes referred to, not unlike the glass jars one sees in confectioners' windows. It is not always advantageous to show floscule in all its loveliness under the microscope, for recently a friend who came in during the evening, was so fascinated in his examination of the creatures, that he became oblivious as to time, and left about one o'clock in the morning. Still, it was excusable, for this was the first time he had ever beheld it. Mr. Slack's description of floscule may help us to form some idea of the shape and movements of this most interesting object :—

'She slowly protruded a dense bunch of fine long hairs, which quivered in the light, and shone with a delicate bluish green lustre, here and there varied by opaline tints. The hairs were thrust out in a mass, somewhat after the mode in which the old fashioned telescope hearth-brooms were made to put forth their bristles. As soon as they are completely everted, together with the upper portion of the floscule, six lobes gradually separated (I have only detected five), causing the hairs to fall on all sides in a graceful shower, and when the process was complete they remained perfectly motionless, in six hollow fan-shaped tufts, one being attached to a lobe.' Thus we see how each person perceives objects under examination. If we could record the impressions made on the vision and mind of fifty different people, we should find some new fact either in point of structure or in methods of movement, as observed by each individual. With creatures so very minute, it is not easy to find language to express what we see. The accomplished writer of *Pond Life* receives the mental impression of an 'old-fashioned telescope hearth-broom.' To my sight was conveyed the impression of a lovely vase, with five points, having five festooning curves between them, while the points seem like small electric lamps, the cilia, or feelers, completing the resemblance to rays of electric light. One can see but little resemblance between an old-fashioned hearth-broom and a lovely vase, yet both ideas are perfectly in accordance with this extraordinary creature's shapes and behaviour. As in many other cases, we recommend a personal examination of the object with a good microscope.

One peep will not satisfy you, but it will be better than any description ever given by any writer, however capable an observer he may be. I feel certain, too, that no author will feel aggrieved at this statement. There is one other feature you must remember to notice when engaged in viewing the beautiful floscule, and that is, the face of the clock, or of the watch in your pocket.

VOLVOX.

If we were to send to our friends who have microscopes, and who live within a reasonable distance, the simple message, 'Come and see volvox,' we should receive at once prompt response to the invitation. And this, moreover, from those of our neighbours who see this object as regularly as the summer comes round. These four simple words contain sufficient magnetism to draw together a considerable gathering for an evening's intellectual enjoyment.

The secret rests not merely in the fact that volvox is both beautiful and essentially microscopic, but in that it is a *plant endowed with powers of locomotion.*

Our microscopes are arranged, but a friend arrives who has never seen volvox. To him the first view is conceded, and all are curious to hear his opinion, though they can readily

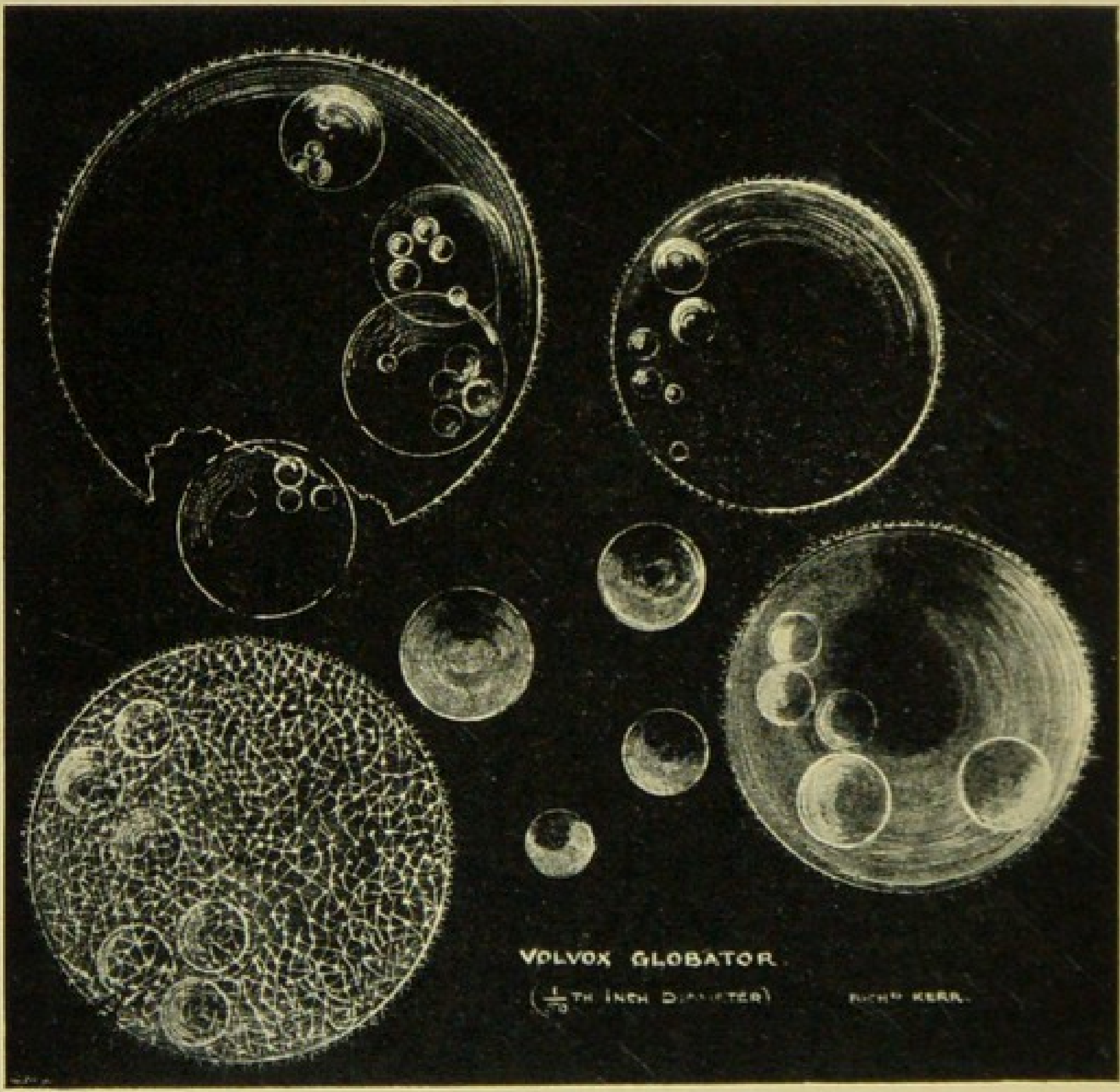

Fig. 51.—Volvox globator. $\frac{1}{50}$th of an inch in diameter.

anticipate some of his exclamations, which are as follows :—

'This is astronomy, these are not microscopic objects, for here are worlds revolving, some are gliding along most gracefully while others are spinning on their axes—the light shows me they are translucently green, and that there are "other worlds" inside of these, and they too are rotating!'

The volvox plants our friend has been viewing do most certainly resemble revolving worlds, hence the name Volvox globator, yet they are individually only the fiftieth part of an inch in diameter.

A great deal of discussion has arisen as to whether volvox is a plant or an animal. While several naturalists of high position have classed it along with animal life, the greater number agree in pronouncing it to be a true plant. It is no easy matter, nowadays, to frame a definition which will draw a line of demarcation between the animal and vegetable kingdoms. In our younger days we used to be told that the great difference between plants and animals lay in the fact that animals were free to move about, but that plants were fixed to one spot, having no power of locomotion. Since those times we have learnt the fallacy of that definition, inasmuch as certain plants, volvox among the number, have power to move about, and are provided with organs specially adapted to enable them to move! While, on the other hand, there are animals which are always fixed, and are consequently unendowed with locomotory accessories. That the rapid movements of the volvox are in no way dependent upon, nor caused by currents in the water in which they live, will be shown presently.

It is at this stage necessary to mention, for the sake of beginners, something as to how and where volvox is to be obtained. Many of our English ponds and dykes are so filled with specimens of these fascinating organisms that the water when held up to the light presents a semi-transparent green colour, every portion of its contents displaying the greatest activity. The micro-plants are fond of sunshine, and as they come to the surface they may be easily captured in a glass tube which is open at each extremity, and having a bit of fine muslin secured with an elastic band to one of its ends. This allows the water to pass through while it retains the specimens. The thumb may then be placed at the muslin end, and the contents poured into a bottle. Experienced microscopists advise us not to mix the water of different ponds. It will be advisable to examine them soon after you have captured them, for few have the secret of knowing how to keep them for long. They thrive in the light and in fresh air. It has not been our good fortune to preserve them for more than three or four days at a time.

Owing to the incessant motion which characterises all the healthy specimens, it is no easy matter to photograph them through the microscope, or to make a careful sketch for purposes of illustration.

The old-fashioned and nearly obsolete exhortation given by the photographer preparatory to taking a portrait, 'Steady now, please; one, two, three,' would be wasted in this case, for the volvoces would have spun round more than a dozen times on their axes, and plants have no regard for our language; yet they have been rapidly photographed by the Sciopticon Company of Highbury Quadrant, and by Mr. Hambridge, the clever amateur photographer of Folkestone, so that we are enabled, in the absence of the living plants, to place slides of volvox in our lanterns, and thereby show the general structure of this remarkable object, tremendously enlarged, to our audiences.

One of these tiny plants in a miniature tank of water, placed under a microscope, is an object of marvellous beauty. The light passes through its green sphere and reveals a beautiful membraneous envelope, studded at regular intervals with points of green, which under a higher power show the ever busy and mysterious cilia or lashes.

We must now show that the moving power possessed by volvox is no haphazard motion. Take a single specimen in a drop of water, place it in a live-box, or between two thin glass slips, very gently press it, so as to retain it in one position without causing it to burst. Then view it with a one-fifth objective and a good light. Pairs of cilia, before invisible, will now be seen at intervals along its surface. Although the volvox is in captivity, yet the cilia are most energetic, lashing the water in one direction and producing very decided currents, showing thereby the work they do when the sphere is free. This vigorous lashing of the cilia so resembles a voluntary act that we unthinkingly find ourselves asking whether the volvox has a will or a mind of its own. One cannot easily comprehend a plant having such decided power, and that power directed in an orderly method and resulting in definite ends.

The fiftieth part of an inch is not a great space in creation, yet a wonderful plant, wonderfully endowed, and possessed of powers which baffle man's knowledge, occupies that minute limit.

A rent appears in the envelope of the full-grown volvox, and the enclosed young volvoces escape. Their cilia lash the water, and away they go, rolling and spinning like so many animated green balls, never appearing to collide with each other. In time they grow to the size of the parent volvox, become filled with tiny volvoces, burst their envelopes, and thus complete the cycle of their life.

Sunshine and ciliary action may account for a great deal in the life-history of this astounding plant ; but there is beyond these a power which man can neither understand nor define, and that is *life*.

CHAPTER XVII

SNOW AND WINDOW-PANE CRYSTALS

THERE are times when the cold is so keen, that it is not necessary to place snow under the microscope in order to see its beauty, for the crystals can be discerned with unassisted vision. This is, however, not of frequent occurrence. Water is a mineral, and whether it appears as snow, ice, or hail, it must obey certain laws. One of these laws is that it must assume certain definite shapes when it is deprived of its heat. Therefore, with other minerals, it obeys the law of crystallisation. Each crystal and each face of each crystal is inclined towards its neighbour at certain definite angles, and cannot take up any other position.

Snow is ice, only it is in a minute form, so thin, indeed, that it comes down gently, floating about on the breeze, and not suddenly, like hail. One can hardly imagine that snow is ice, for the latter is so heavy and compact compared with the former. The former, too, is much whiter than ice; but if we pound ice into small granules it becomes as white as snow. A com-

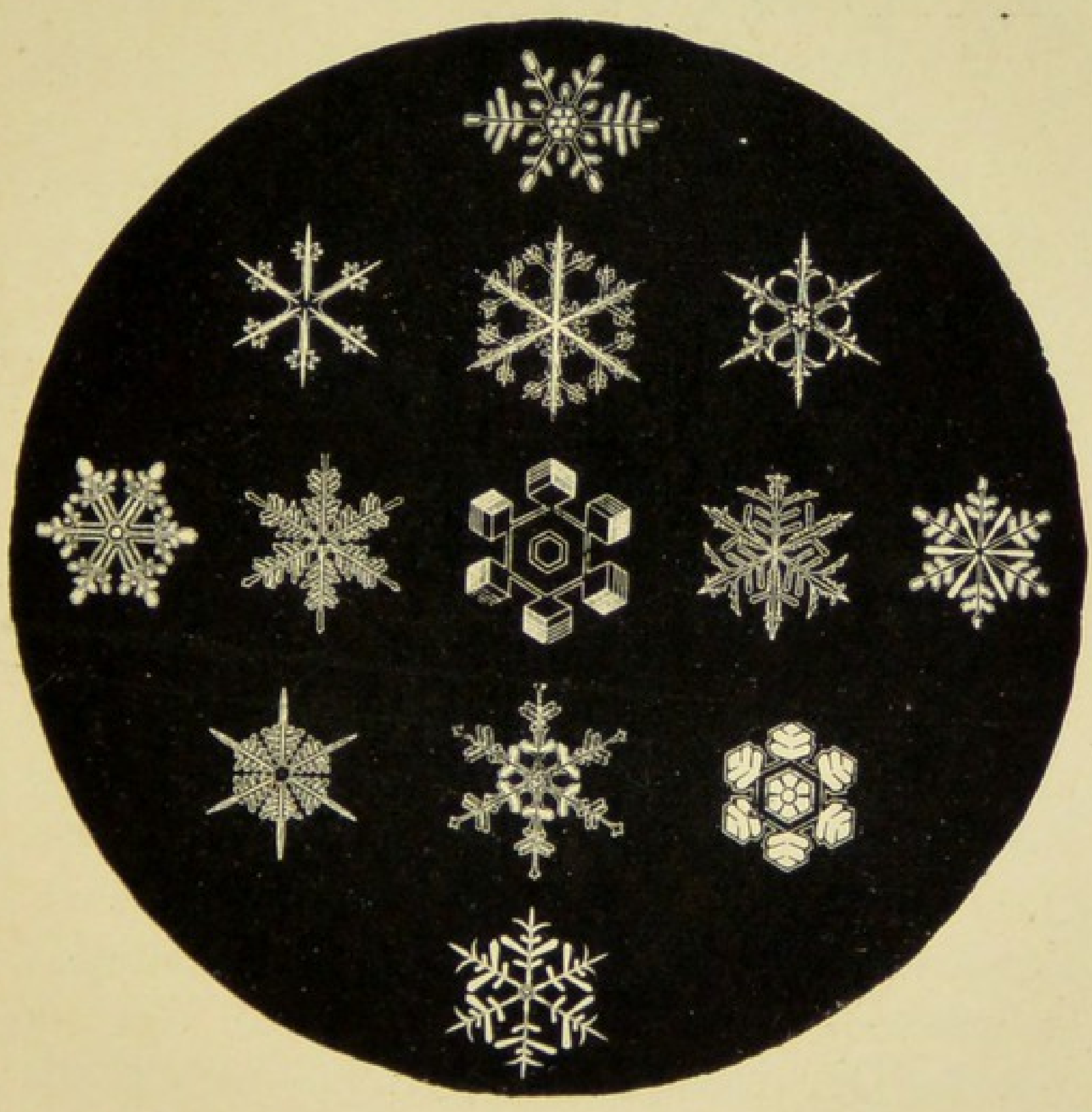

Fig 52.—Snow Crystals.

parison of the specific gravity of the two, ice and snow, leads us to think there is a great difference between them; but, as a parallelism, gold appears to be much heavier than gold leaf, whereas the latter is but the result obtained by hammering out the solid gold until it becomes so light that it floats about on the breeze, as does the snow.

If we take a microscope out of doors during a snow shower, and place an umbrella over it, we may catch a falling flake upon a glass slip, and as we have it under examination in a uniform temperature equal to that of the surrounding air, we shall be able to study the flake for some time, and to repeat the experiment with many other flakes. It is just possible that we may not find two crystals alike. In fact, we may hit upon some forms of crystals which have never been seen by any other observer, for there is no end to the variety of forms which a drop of water may assume in its passage from the clouds through several strata of cold air. The accurate regularity which characterises every crystal is bound to command attention. Although this power to take on special shapes is not growth from within, nor yet life, such as is possessed by plants and animals, yet there is something about this power which is mysterious and most impressive. The accretions arrange themselves into well-defined shapes, or rather, are controlled by unerring laws, so that they cannot coalesce in haphazard fashion, but are so ruled that the sum total of the crystallising power produces beautiful designs. Surely all this is a part of that wisdom which is observed throughout all Nature. The crystals of the minerals join with the flowers, the birds, mankind, and all other created things, in saying, 'The Hand that made us is Divine.'

Although snow is so very light and thin, it appears opaque to our vision. This arises, it is thought, from the fact that each crystal contains air. This causes the light to be internally reflected. A similar effect is noticed by every one examining pond water under the microscope. A bubble of air is present, and with the exception of a tiny point of white in its centre, the whole bubble appears to be black, the light being internally reflected except at the central point, through which the rays pass in a vertical direction to the eye. Bulk for bulk, ice contains less air than snow, and is therefore much more transparent. The crystals of snow are, however, so wonderfully arranged that they all unite in reflecting to the eye from their own surfaces the greatest possible amount of light, thus producing the sensation of whiteness.

Dr. Scoresby sketched out ninety-six different forms of snow-crystals during one of his voyages in the Arctic regions. The presence of animal or vegetable organisms occasionally adds colour to the snow, so that at times in northern climates it appears of a red or orange colour.

Snow-water is said to contain a greater percentage of oxygen than either rain or river water.

This may be proved by analysis; but if three bars of iron of uniform quality be exposed to the action of river-water, rain, and snow, respectively, that under the influence of snow will be found to have oxidised more than the others. Its rust will be more apparent.

In Nature the snow performs a great work, owing to the gradual way in which it thaws on the mountain tops, and thus supplies streams of running water. In this respect it is less destructive than rain. A sudden downpour of rain sweeps all before it.

In hot climates snow tempers and modifies the burning heat by cooling the winds that travel over the snow-clad mountain tops. In temperate climates it protects the plants against the frost, owing to the air it contains, and in the northern regions it serves as a shelter to the animals which bury themselves in it. A winter without snow is a destructive one for plants. There are at least fifteen references to snow in the Bible, the most beautiful being David's request in the 51st Psalm: 'Wash me, and I shall be whiter than snow.'

In the Book of Job snow is mentioned on four occasions, the last is in the 38th chapter, where the Lord interrogates Job, and reviews Nature both as regards this earth and also as regards the stars in the heavens, a chapter that cannot fail to impress every one who reads it as it should be read.

Professor Huxley says: 'More than a thousand different kinds of snow crystals have been described, but various as these are, they are all characterised by the same kind of symmetry.

'The most perfectly shaped crystals are formed when the air is still; but if a rough wind prevails the snow may fall in pellets, or if the snow passes through a layer of warm air it arrives on the earth as sleet. As snow is one-tenth the weight of an equal bulk of rain, it follows that a fall of snow ten inches deep will be equivalent to a fall of rain one inch deep. The loose texture of snow renders it an extremely bad conductor of heat, hence a fall of snow thus acts like a mantle of fur thrown over the earth.'

Dr. Maddox, the skilful microscopist, is credited with the following experiment:—

It is said that he breathed on the window-pane in his room during frosty weather, then bringing his microscope towards the pane he carefully focussed the objective, and looking through, he saw that a number of curious crystals were formed. Possibly the chemical contents of the breath along with the moisture took on definite shapes, as is the case in most mineral substances. He is then said to have attached his camera to the microscope, and to have taken a photograph through the microscope. A copy of that photograph, which I purchased some years ago at How's, in Farringdon Street, forms fig. 53. This must not be mistaken for a direct photograph of a considerable portion of the surface of the pane of glass, for, at the time, I was led to understand the space photographed was about the tenth of an inch in diameter.

If this be so, and I have no doubt about it, we have a wonderful collection of crystals, each different pattern representing some special chemical substance, showing the same law referred to in the remarks on snow crystals. The whole area of one-tenth of an inch is not a

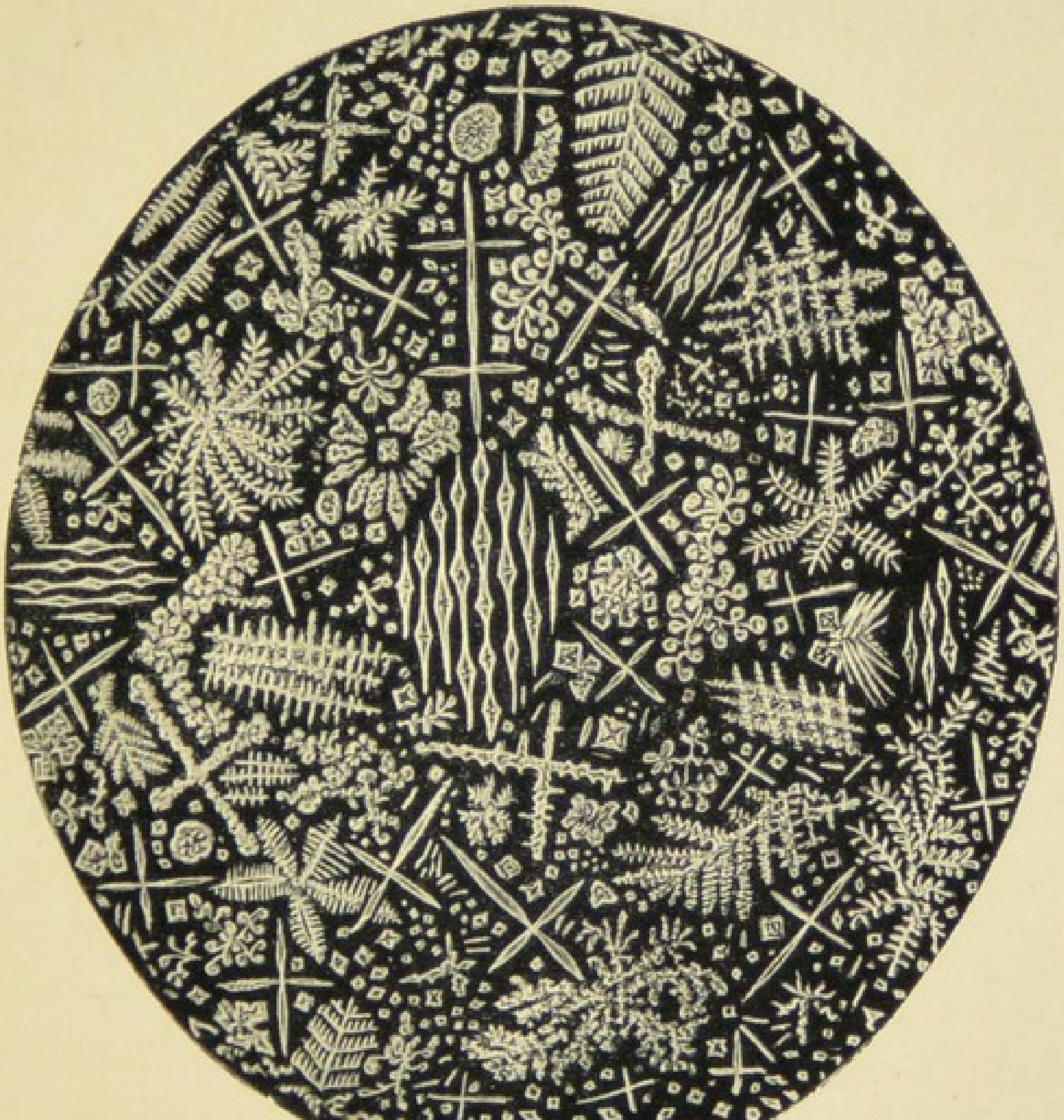

Fig. 53.—Crystals formed by breathing on a window during frost.

The photograph, taken through the microscope by Dr. Maddox, embraced only $\frac{1}{10}$th of an inch.

very extensive field of view, yet it contains a vast number of lines, for it took me over two hours to go over them in Chinese white, with an ordinary writing pen, which I never could have done, but that the tenth of an inch had been amplified considerably.

CHAPTER XVIII

THE EYES OF INSECTS

WE feel compelled to make some reference to the eyes of insects, because they are extremely wonderful. Amplify them however much we may, there is no possibility of any weak point being found in their symmetry. The eye of the water beetle (Dytiscus marginalis) is as surprising as that of any other insect. In fact, the whole structure of this creature is one series of marvels. A lecture dealing with this creature alone would be enough to entertain any audience.

A very small portion of its eye is shown in fig. 54. It is very difficult to photograph this object properly because of its curved shape. Still if we had not tried to improve the photograph it would have been more perfect.

Fig. 55 represents a very small portion of the eye of a house-fly. It shows a series of hexagons quite separate from each other. Only high powers can show this effect. A

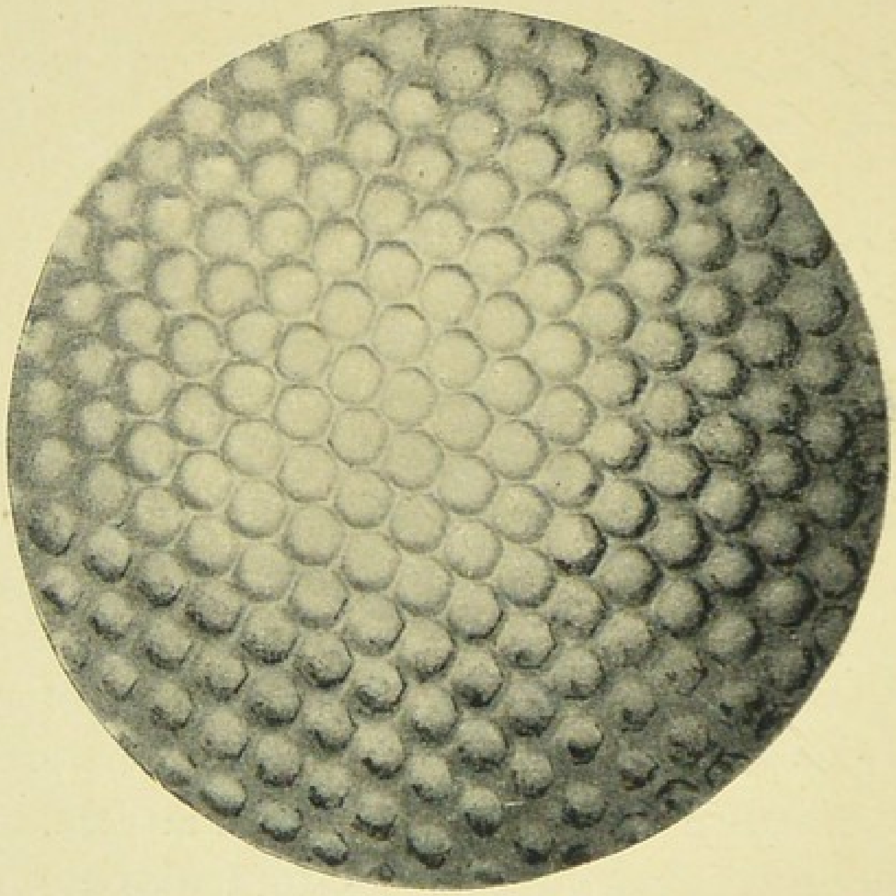

Fig. 54.—A small portion of Eye of Water Beetle (Dytiscus marginalis). Enormously magnified.

lower power shows all the hexagons uniting to form a network arrangement.

There are some thousands of these facets or ocelli in the eyes of any insect—whether fly, bee, or beetle, yet it does not follow that so many images are depicted on the creature's retina or conveyed to its brain.

If an image of any object should fall on one

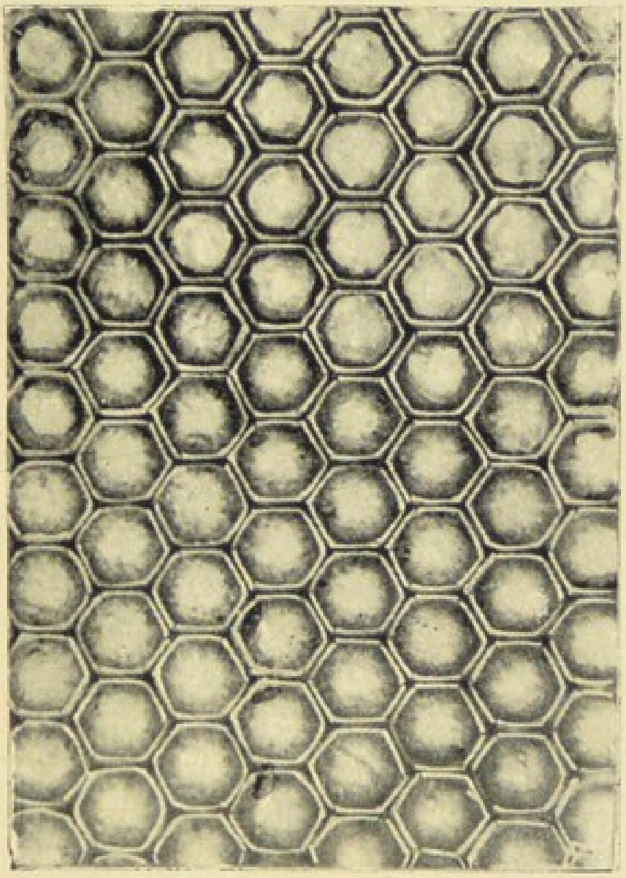

Fig. 55.—A small portion of Eye of House Fly.

facet, that image would be sufficient to enable the creature to see the object.

If the microscope be arranged in a vertical position, and only one tube used, a very interesting effect may be produced by placing a portion of the eye of an insect so that when nicely focussed we see right through it on to the second hand of a white-plated watch.

If we are looking through a hundred facets of the insect's eye, we shall be able to see a hundred images of the second hand. When the tiny hand is in motion the effect is most telling. It does not follow from this that the insect sees a multitude of images of any one object.

The eyes of insects are very small, and to be seen properly must be viewed under the microscope; yet we are told by Dr. Carpenter, in the 'two eyes of the common fly there are as many as 4,000 ocelli or facets; in the eyes of the cabbage-butterfly there are about 17,000; in the dragon-fly 24,000; and in the mordella beetle 25,000!' Such figures as these, descriptive of mere points, if well considered, appal us much in the same manner as do the calculations connected with astronomy.

Leuwenhoek, more than 200 years ago, arranged the eye of an insect so that he was able to see through the facets, and could see buildings many yards distant so distinctly that he could tell which windows were open and which shut. This famous microscopist, although using very inferior magnifying powers, was well acquainted with a great deal of what is now known and revealed by greatly improved appliances.

CHAPTER XIX

THE PROBOSCIS OF THE BLOW-FLY

EVERY one using a microscope is familiar with this astounding object (fig. 56). It is a common practice to magnify this object right up to several feet in diameter, and still the more it is enlarged the more perfect it becomes.

Any object in Nature will stand enlargement and still show regularity, but there is scarcely any prepared slide in existence that equals this one. We enlarge the object some few hundred diameters, and we see parts that were quite invisible before, now standing out splendidly; but as we still proceed to enlarge it the tubes begin to attract our attention. We find they are not closed in, like an ordinary tube or pipe of india-rubber or lead. The tubes are open along their length, and the two edges of each are beautifully scalloped and fringed. As a lantern slide, when the image is enlarged on a screen 20 feet in diameter, the proboscis still bears the closest inspection, and is always greeted with rounds of applause. No loco-

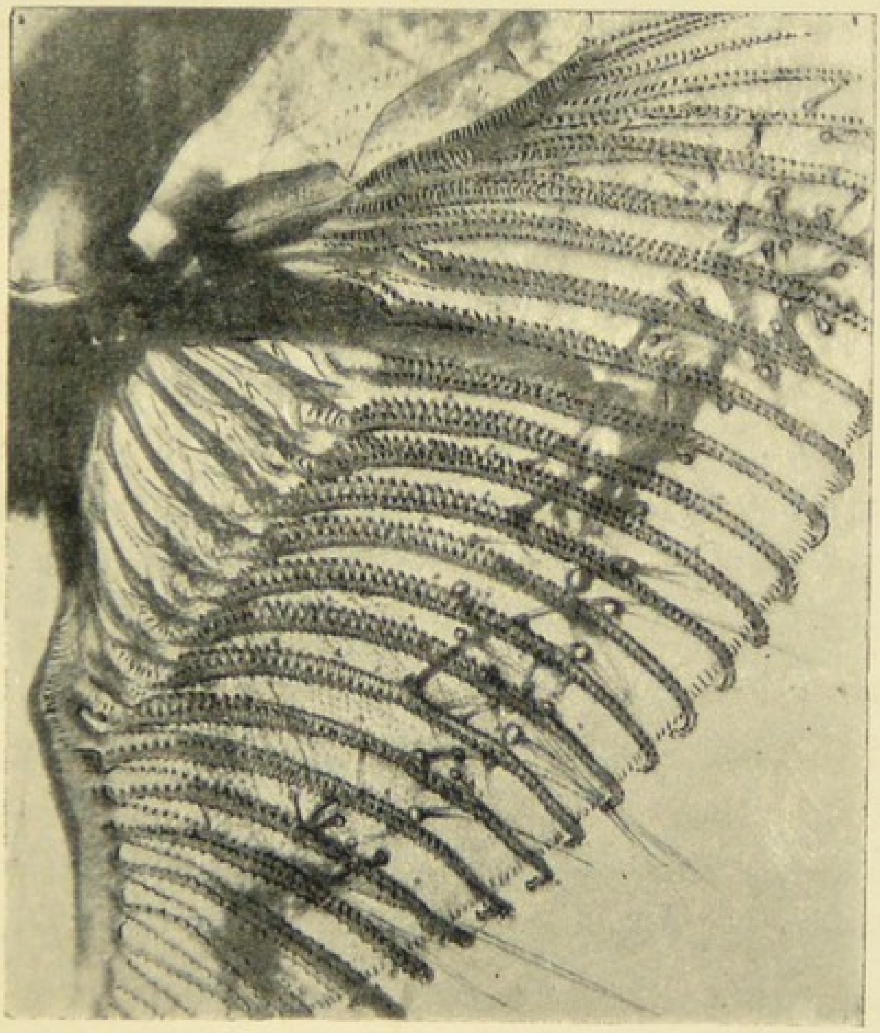

Fig. 56.—A portion of a Blow-fly's Proboscis. Enormously magnified.

motive engine has ever been constructed that is half so wonderful as the proboscis of the blow-fly.

Another object easy to be obtained, and

which affords immense pleasure, is a section of a common rush, proving that it is not always necessary to purchase slides for examination when we have a microscope. There are many slides which one might have in reserve for use at any moment, but there are subjects like the rush, that if taken fresh and examined are preferable to dried-up specimens.

The structure of the pith of the rush is quite beyond our powers of description.

When enlarged, as on a screen in the lecture hall, I always recommend it to ladies as a pattern for a wool-worked shawl. The triangular arrangement of air cells is as surprising as anything we should meet with in all the vegetable kingdom, and we see at a glance how it is that when pressed between the finger and thumb and let go again the rush assumes its usual shape.

Time would fail to enumerate the beautiful objects revealed by the microscope even in those things that we rudely call 'common.'

All Nature bears the impress of wisdom and skill that must make us feel humble in the sight of our good Creator. If our eyes were trained to see as we ought to see, we should derive more benefit and pleasure from our country walks.

Let me give you an illustration, which requires no microscopical aid, but is a direct result of observation :—

The hill-side sloping away to yonder meadow is carpeted with daisies (the day's eyes), and now in the early morning we see that all these humble flowers are not only opening out, but their stems are inclining towards the east, making a small angle with the horizon, stretching, as it were, to greet the sun as he rises. The earth rotates, and as mid-day approaches the sun appears to have reached a point nearly over our heads. The daisies have followed his course, and are now standing in vertical order. The earth continues his daily rotation until the sun's rays fall obliquely upon our extensive carpet, and all the daisies, as if sorry to be parted from its benign influence, keep their gaze in his direction until their stems reach a similar angle to that commenced in the morning, only towards the opposite point of the compass, and they only close for the evening as their friend says 'Good-bye.' Thus an arc of many degrees has been described by each of the millions of 'white and gold' flowers on our hill-side. This is but one of Nature's simple performances, yet it is rarely noticed.

CHAPTER XX

A SEASIDE RAMBLE IN SEARCH OF HIDDEN BEAUTIES [1]

A VERY good acquaintance with many of the hidden beauties of Nature may be gained from a ramble at the seaside or along a country lane. The eye receives training and the faculties of observation are educated. If the memory be helped by means of the eye, it is more likely to retain impressions than if it had received them through the ear alone. This fact is more recognised now than it used to be. The rising generation has therefore many advantages never enjoyed by their ancestors. Books are better illustrated. Lessons and lectures are made attractive and intelligible by pictures and lantern slides; and in addition, museums are more numerous in which Natural History objects are properly classified.

[1] The greater part of this chapter appeared in the *Dover*

Natural History can best be understood by direct contact with Nature. In these countries there is little to fear when we are seeking out some of Nature's attractive secrets, and I know of no more enjoyable way in which to spend a day's holiday than by walking along a pebbly beach collecting objects cast up by the sea, or searching for interesting pebbles and fossils.

Let us imagine ourselves at Folkestone, for instance. The day is fine, and the tide is receding. This is necessary, because at full tide the waves wash against the chalk cliffs near Dover, and we should be unable to proceed. In the neighbourhood of cliffs that are not easily climbed it is always advisable to ascertain the time of full tide, so that a sufficient margin be allowed for any proposed journey. We are about to walk to Dover along the shore.

In order to enjoy the ramble it will be necessary to have a stone-cracking implement, a stone-cracking propensity, a strong bag, a strong pair of boots, a substantial lunch, and a moderate amount of ordinary gumption.

Standard as an article, entitled, 'A Geological Ramble from Folkestone to Dover,' contributed by the writer of this volume.

Some of these requisites will not need any description, but in order to save disappointment, a few words as to the 'implement' will not be amiss. Avoid the so-called geological hammer, which has a square face and a long spike, mounted on a fragile handle. The square end is not adapted to flint-smashing, and the long point if used as a lever will either break or cause the handle to give way. The hammer should be solid steel, excepting, as a matter of course, the handle, which should be of wood. A piece of ash does well, scarcely anything better. One end of the head should be shaped like a small hatchet, the edge in a plane with the handle; the other end a solid cylinder of steel, about two inches long, having a round striking extremity; its entire weight about a pound and a half. The hatchet end does splendidly for extricating fossils, such as ammonites (so called from the horns of Jupiter Ammon), from the chalk, while the round end is admirably adapted for opening flints. In fact, to use the words of a friend, 'one end does for the Ammonites and the other for the Hittites.'

Throughout the whole of the journey we shall find an immense amount of material to interest us. The stretch of nearly seven miles contains *in situ* the main divisions of the chalk, gault, and lower greensand. Sallying forth with our hammers, we look like practical dentists, and the appearance now and then of the teeth of an ancient shark, or still more ancient saurian, helps to establish our claims to the dental profession.

Our pleasurable feelings may now be compared to those possessed by a sportsman starting out with his gun across his shoulder and knowing he had plenty of game before him; or of a huntsman who finds himself astride a good horse at the commencement of a good day's run with the hounds; while our day's enjoyment will be less open to question.

There would be less indigestion and more appetite if fossil-hunting expeditions and rambles in search of seashore treasures were more the order of the day. Such a ramble as this will cure an attack of indigestion in quicker time than the best medicine in a chemist's shop.

Commencing operations immediately to the east of Folkestone Harbour in the greensand beds, we soon find some good specimens of a fossil bivalve known as rhynconella. Every line of the original shell is perfect, although no trace of their former shelly composition can be detected. All has been replaced by brilliant iron pyrites, which give the fossils the appear- of gold. The gault bed close by, nearly ninety feet in height, supplies us with some good crystals of selenite, a transparent variety of gypsum or alabaster, a rock which, when found in large quantities and then burnt to expel the water, leaves a powder known as plaster of Paris. The crystals we have found in their natural condition split into thin leaves, thinner than ordinary note-paper, and are used by micro-scopists for producing beautiful polariscopic effects. When you become acquainted with the uses of the polariscope you will appreciate the beauty of these selenite crystals much more than you can at present.

We must not leave Copt Point, the scene of our gault bed, without 'extracting' from it specimens of the following fossils: natica, belemnites, ammonites, hamites, crabs and inocerami. Owing to the fragile nature of these fossils, it is necessary to take out with them the small blocks of gault upon which they rest, and to coat them all over with gum, to preserve their iridescence and to prevent the crumbling which results from exposure to the air.

Here are the remains of an ancient sea beach, the small stones, which were rounded by the rolling action of the tides in days gone by, are now being exposed again, and, instead of being free to roll once more, are firmly cemented together, forming a rock called conglomerate, or pudding-stone. The mention of this last name has suggested thoughts of lunch.

Here are fragments of pottery and one or two flints, a scraper or fire striker, and a flake. These tell us something of the remote people who were located in this neighbourhood, and who possibly rambled on that ancient beach now being exposed by the action of modern waves. The pottery is devoid of regularity of outline and of accurate ornamentation, showing that they knew nothing of the use of the potter's wheel, and probably indicating that they belonged to what is known as the early stone age. This piece of flint was used as a scraper for removing fat, etc., from skins of animals. It may have done duty as a fire-striker, when struck on a piece of iron pyrites. This word 'pyrites' implies a connection with fire. The methods adopted by our grandfathers for lighting a fire with flint and steel were scarcely more expeditious than those employed by the natives of uncivilized countries, or by these pre-historic peoples of whose existence we have such abundant evidence. Among the advances made in recent years few are of more service than the manufacture of matches.

These flint implements that we have now picked up, and many others frequently met with, show a certain fashioning for definite purposes, and naturally lead us to think that these ancient people of the stone age knew nothing whatever of the use of metals.

The tide is now well out, so that we may walk over the Neocomian bed, and see quantities of wood which have been bored by the teredo and pholas. 'How heavy it is!' you exclaim. Yes, it has been covered up by overlying rocks, and has been saturated with water containing iron and sulphur, the two ingredients of our friend iron pyrites. You can see all the rings of woody growth, but if you examine it with this pocket lens you will observe the minute crystals of iron pyrites everywhere through it. This remarkable bed of fossil wood has been exposed by the action of the ever-moving sea.

Those pieces of bright red tiles are evidence of Roman workmanship. The dull-looking pieces yonder belonged to a cottage which stood in a nice garden twenty-four years ago.

Garden and cottage have long since been carried on to the beach by the ever-shifting and unstable gault. Such is the nature of the strata in this locality that the same footpath along the brow of the cliff never does duty for two consecutive years. We are now in the neighbourhood of the undercliff, and we find on all sides an abundance of iron pyrites, in the form of round nodules about the size of tennis balls.

Not unfrequently do the visitors to this spot persist in calling them 'thunderbolts,' while others who find bright samples believe they have found a gold mine. We break a specimen open, and it shows a beautiful gold-like sheen, with radiations from its centre to its entire surface — a veritable hidden beauty. These nodules are used for staining leather; but as both iron and sulphur can be obtained pure or nearly so, this mineral is of little value. Instead of being 'thunderbolts,' they are formed in most of our chalk cliffs.

A much rarer and more beautiful variety of iron pyrites, which we shall find presently, is known as marcasite, or spear pyrites. Each crystal is formed like a spear head. A number of these spear-head crystals sticking out in all directions, and all glistening like gold, makes a specimen worthy of a place in a geological cabinet. Still we must not despise our more common form, but give it also a place side by side with its rarer cousin. It will enhance the educational value of both specimens if we leave them in the surrounding block of chalk, exposing the main portions. The chalk may be cut to a convenient size and shape. Thus the nature of the matrix can be seen at a glance.

In opening up this large block of chalk we find a vein of calc spar, by following which we are led to a small cavity lined with crystals of a yellow tint. These are crystals of calc spar, which we must wrap up in paper, as they are easily broken. Their composition is carbonate of lime. The novice will mistake them for crystals of quartz or silica. But a trial of the hardness, by means of the tip of the penknife, will show them to be of the softer ingredient. They are very beautiful, and worthy of a place among our other trophies.

There are four stones, somewhat rounded, which I picked up as we came along. We'll dip them in the sea, so that we can the more readily examine them for traces of animal life.

There you see are tubes radiating from a kind of ring in the centre of the stone. This cannot be an accident, for much the same characters are to be observed in each of the three other specimens. Now these are well worth the expense of polishing. Few objects are

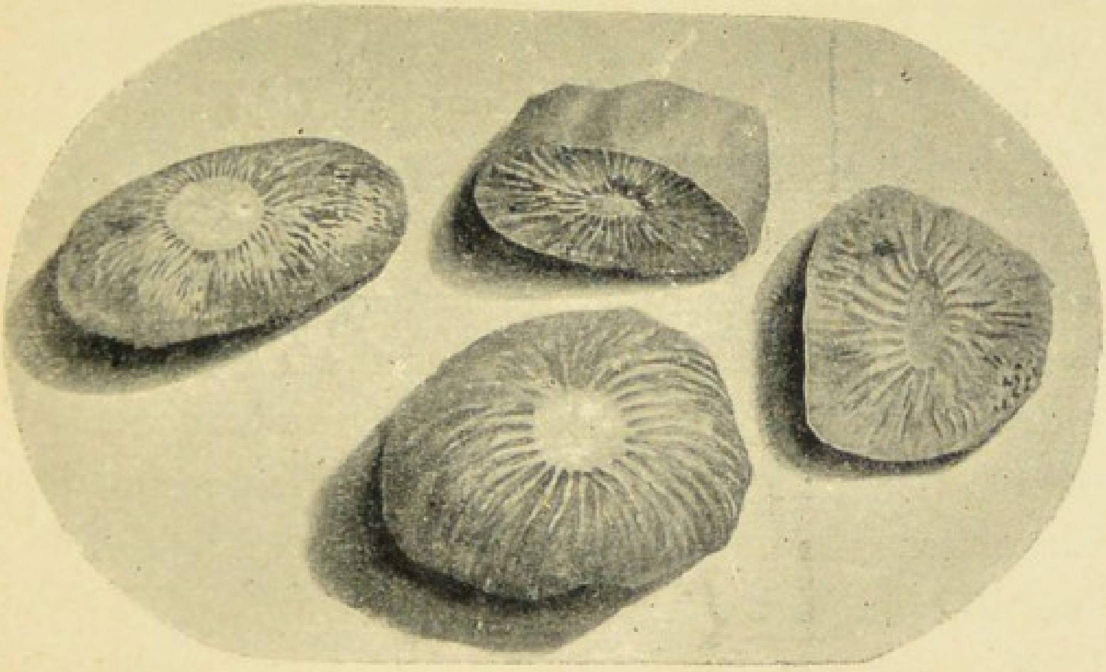

Fig. 57.—Four Flints, showing Silicified Sponges, known as 'Choanites. Natural size.

more fascinating to the collector. They are choanites, so called by Dr. Mantell. But this name simply means a hollow or funnel-shaped body, and conveys but little to our minds. These were sponges, somewhat pear-shaped, which lived on ocean floors long before man came upon this earth. There must have been an abundance of these sponges, for choanites can be found on most pebbly beaches of the South of England. It is doubtful whether similar sponges live now. Those ancient ocean floors have been gradually raised up, so as to form the cliffs and beds of rocks now being worn down by sea action and the weather.

Examine the stones carefully. The tubes so characteristic of the choanite must not be mistaken for feelers. Every sponge has one or more large openings, or oscula, out through which the used-up water flows, while it also possesses quite a multitude of small canals through which the fresh sea water is conveyed to every part of the sponge structure. The markings which we see on the polished choanite, and which resemble feelers, are these smaller canals, which were originally embedded in the jelly-flesh structure known as sarcode.

In the course of the gradual replacement of the sponge by silica or flinty matter, certain colouring substances, such as oxides of metals, in solution in the water, found their way into the sponge, and produced the lovely tints revealed by the polishing.

An examination of a case full of choanites in the Brighton Museum ought to be enough to prompt any one seeking a healthy pastime to at once decide upon starting a collection of these most charming objects. Hundreds, doubtless thousands, of these lovely stones are being rolled about on several south coast beaches, and may be discerned by any industrious seeker.

That they are hidden beauties of Nature is apparent to any one who is acquainted with them. The wheel and the powder and all the accessories used by the lapidary to cut and polish them, are necessary in order to bring out their loveliness, reminding us of some splendid characters we occasionally meet, whose lives become more and more beautiful under the chastening processes of trial and sorrow.

But we must proceed with our journey towards Dover. This is called Lydden Spout, a famous place for flints.

On opening this flint we find it is lined with a translucent substance, which is intensely hard. This is a pure variety of silica or flint, known as chalcedony. The two halves of the flint must be placed side by side in the cabinet, to show their concavities.

In the neighbourhood of Clifton Suspension Bridge, the hollow stones are lined with another variety of silica, *i.e.* quartz crystals. These lined with chalcedony also are very beautiful.

I generally find traces of sponges in all flints lined with this beautiful mineral. But we shall not have to look very long before we find the ancient glass sponges, which lived when warmer waters occupied the place of this Channel and of the land on which we are walking. Glass or flint sponges lived in large numbers about here on an ocean bed. Their bodies in every detail have been succeeded by flint, and so marvellously quietly has the Change taken place that even the microscopic spicules of the flinty chain-armour which were embedded in the ancient creatures' fleshy substance can now be detected in the layer of flint after it has been thinned down and polished (fig. 58). Here are two flints broken open to show the nucleus in each instance (see chapter on Euplectella). These flinty specimens are known as ventriculites, and were quite an enigma to our geologists, until the 'Venus's flower basket' was brought to this country from the depths of the Philippine Seas.

What was thought to be an extinct organism was found to have plenty of representatives. It may be so in the case of the choanites.

Here are traces of other forms of the sponge family embedded in the chalk. These must

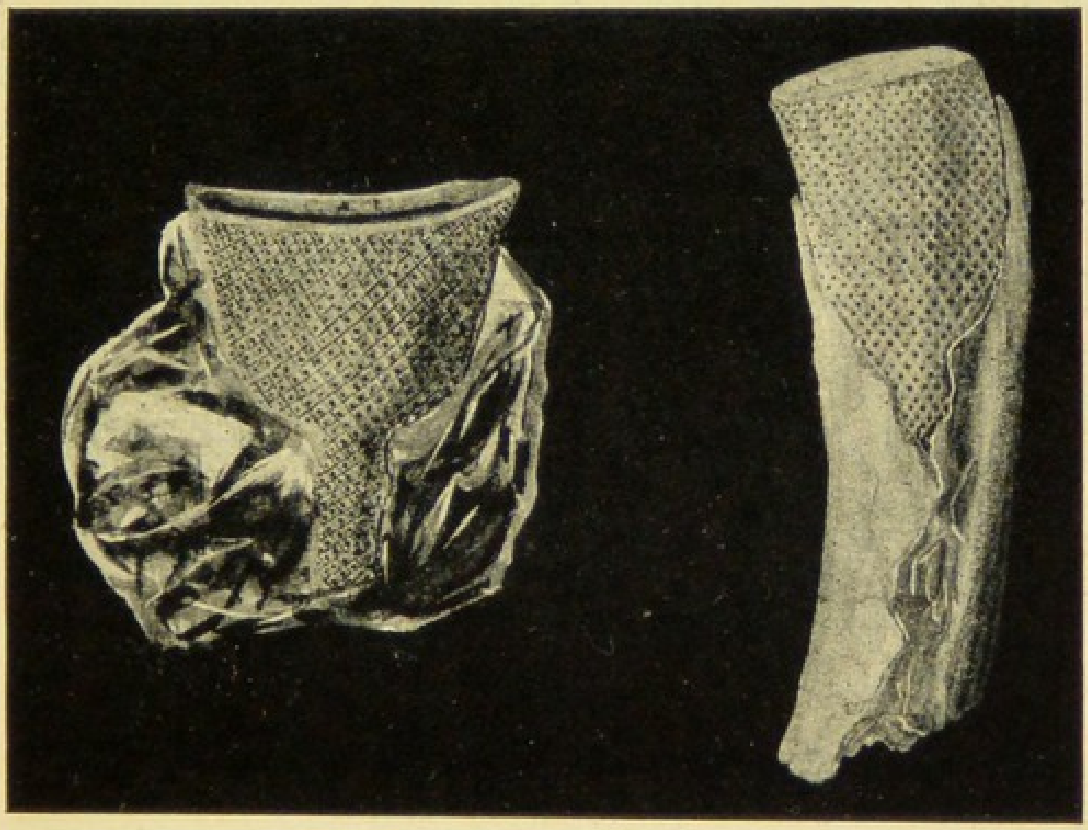

Fig. 58.—Silicified Sponges in Flint.

be taken home and carefully worked out with all the patience you can command. They will well repay any trouble expended upon them. There are also some small corals well worth our attention. In this stream coming out from the base of the cliff we shall find tiny ammonites, all of which are replaced by the

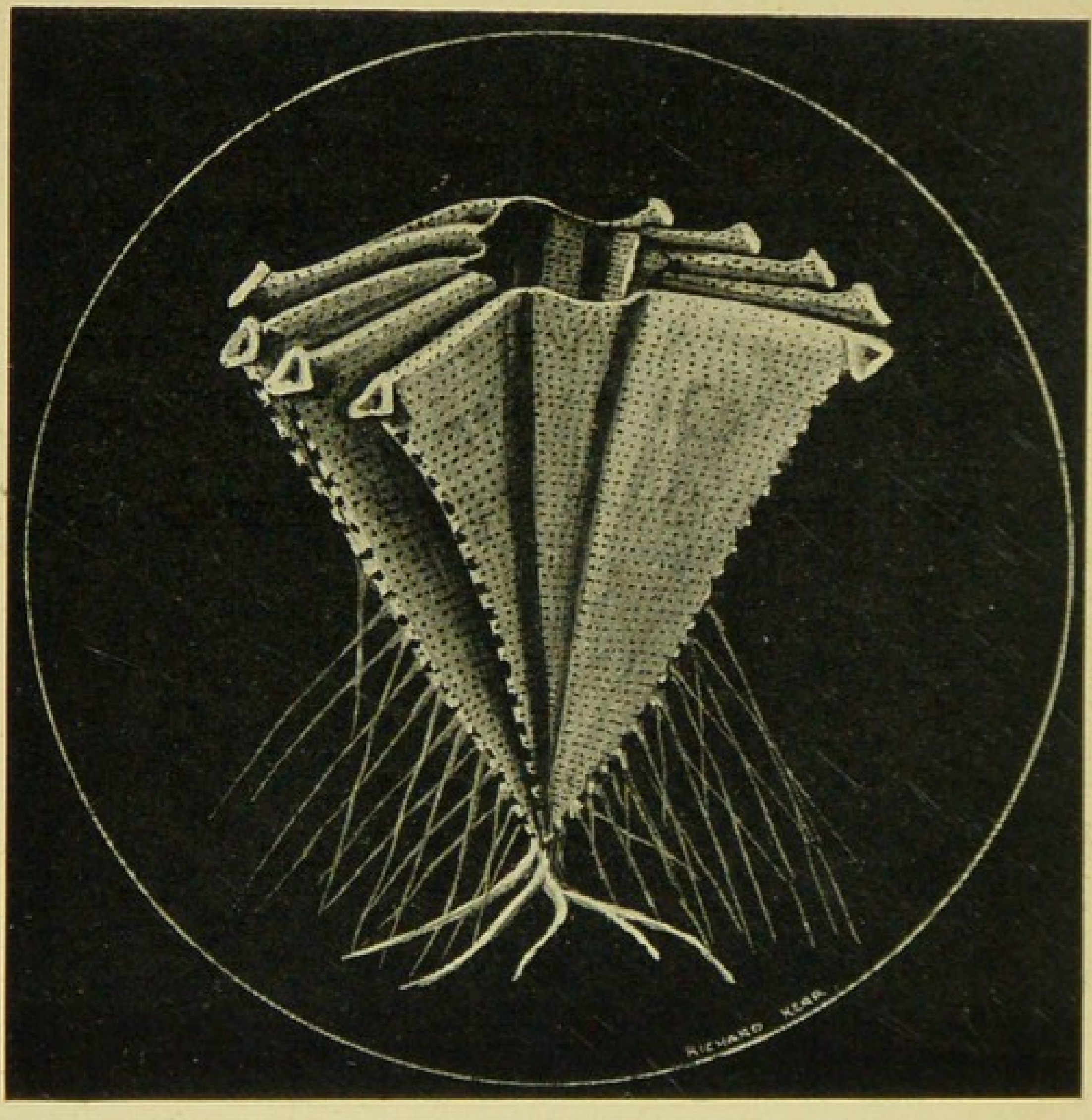

Fig. 59.—Guettardia stellata (Michelin).

prevailing iron pyrites. Collectors frequently have them mounted as trinkets.

This is a fragment of a lovely fossil sponge.

Mr. Toulmin Smith, some years ago, found sufficient of this kind of sponge to construct a very splendid specimen (fig. 59). The creature had wing-like appendages radiating from a central tube or funnel, and was furnished with roots and anchoring apparatus, to enable it to maintain an upright posture. No living sponge has ever been found at all approaching this in shape.

We are now nearing the locality occupied by the Channel Tunnel works, and as the tide is flowing, we must ascend by the steps over Shakespeare Cliff Tunnel. It is tiring work, but the view from the top will repay us. There is the French coast about twenty-one miles away.

On reaching home we must carefully and tidily arrange our specimens. They should then be labelled, and as opportunity occurs it is well to make notes about them, and to read any books which describe their history.

In this way the seaside walk bears good fruit, for you will find that there are many friends who will be most thankful for any reliable information about the specimens collected, and you yourself will, while taking in fresh air and exercising your physical powers, be gaining knowledge by a process that cannot be excelled.

Beyond all this, you are learning more about the marvellous works of the Creator, and your conceptions of His wisdom ought thereby to be very much augmented.

INDEX

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